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Benefits and Costs of Diverting 0.2 MGD Influent from Los Alamos County Wastewater System to Los Alamos National Laboratory Sanitary Wastewater System

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ABSTRACT

The Sanitary Waste System (SWS) at Los Alamos National Laboratory (LANL) is an extended-air, activated sludge wastewater treatment facility that is designed to treat 0.6 million gallons per day (MGD). However, the facility rarely receives more than 0.3 MGD and occasionally less than 0.1 MGD. Lack of sufficient flow and organic concentration into SWS, particularly on weekends and holidays, results in an inconsistent and often very low biochemical oxygen demand (BOD). Shortage of organic material leads to routine operation weaknesses and leaves SWS vulnerable to significant problems resulting from small amounts of toxic influents. The addition of residential influent from Los Alamos County will supply organic load to decrease this vulnerability, and improve nitrification during cold weather, weekends and holidays. Additional benefits include conservation of 223 acre-feet per year and savings over 20 years of between \$.6M and \$5.6M, depending on whether project dollars are discounted or not discounted. The project will also generate significant benefits not easily quantified, such as water for future LANL projects, and good will in the community.

CONTENTS

CONTENTS (continued)

FIGURES

TABLES

Table **Page**

ACRONYMS AND ABBREVIATIONS

AB	aeration basin
AFY	acre feet per year
BOD	biochemical oxygen demand
Cl	chlorine
DO	dissolved oxygen
DOE	U.S. Department of Energy
ES&H	Environment Safety and Health
FMU	Facility Management Unit
EQ	equalization basin
JCNNM	Johnson Control Northern New Mexico is contracted by LANL for much of the facility work. JCNNM runs SWS and the environmental lab (HENV) that processes SWS samples
LAC	Los Alamos County
LANL	Los Alamos National Laboratory
MGD	Million gallon(s) per day
mg/L	Milligrams per Liter
MLVSS	Mixed liquor volatile suspended solids
NaCl	sodium chloride
NPDES	National Pollution and Discharge Elimination System
lbs/day	pounds per day
PCBs	polychlorinated biphenyls
RAS	return activated sludge
SWS	Sanitary Wastewater System
SWSC	Sanitary Wastewater Systems Consolidation
TA	technical area
TSS	total suspended solids
WWTP	Wastewater Treatment Plant
WAS	waste activated sludge
WAC	waste acceptance criteria

1.0 INTRODUCTION

Project Objectives

Benefits and Costs of Diverting 0.2 MGD Influent from Los Alamos County Wastewater System to Los Alamos National Laboratory Sanitary Wastewater System is a documented evaluation of the economic and environmental assets and liabilities of implementing this project. The specific objectives are 1) to stabilize the operation of the Sanitary Wastewater Treatment plant at Los Alamos National Laboratory (LANL), and 2) to conserve water by reusing the additional treated effluent.

Project Process

The process was guided by the logical development of this idea to augment flow and organic load in order to resolve plant difficulties.

1) To research and document the history of Sanitary Wastewater System (SWS) problems and proposed solutions to inconsistent organic loading.

2) To interface with all technical areas at LANL involved with this project in order to discuss anticipated compliance issues imposed by New Mexico Environment Department (NMED), U.S. Environmental Protection Agency (EPA), DOE, and Los Alamos County (LAC). Meet with technical staff at the SWS, Facility Waste Operations (FWO), Environmental Safety and Health (ESH-18) groups that deals with permits and outfalls. Meet with DOE staff for funding.

3) To schedule a Design Charrette on April 13, 2000 so all players can meet, discuss and resolve issues with the potential to derail project.

4) To contract Jacobs Engineering to do a feasibility report and cost estimate. Evaluate the accuracy of drafts with LANL technical staff and suggest alterations.

5) To enhance understanding of the biological wastewater treatment process by spending time in the Espanola Wastewater Treatment plant as an intern, culminating in testing for and receiving a New Mexico Utility Operator Certification for Wastewater Systems No. 1.

History of LANL Sanitary Wastewater System (SWS)

The Sanitary Wastewater System (SWS) plant began operations during August 1992. It is the only continuously operating sanitary wastewater treatment facility at LANL. SWS piping connects laboratory technical areas via toilets, sinks (bathroom, kitchen, and laboratory) and floor drains and serves one non-LANL site, the Royal Crest Trailer Park. These areas cover a total of 43 square miles and more than 1200 buildings. SWS is located in Canada del Buey at Technical Area (TA)-46 (Figure 1).

SWS is designed to be a 0.6 million gallon per day (MGD) extended air, activated sludge wastewater treatment system. The SWS facility operates under National Pollution Discharge Elimination System (NPDES) Permit No. NM0028355, issued by the U.S. Environmental Protection Agency, Region 6. Table 1 indicates NPDES compliance standards for LANL.

Table 1. National Pollution Discharge Elimination System Compliance Standards for Sanitary Wastewater System at Los Alamos National Laboratory

Parameter	Monthly Average	Daily Maximum
Biochemical Oxygen Demand (BOD)	30 mg/L	45 mg/L
Total Suspended Solids (TSS)	30 mg/L	45 mg/L
Fecal Coliform (colonies/100ml)	500	500
pH	6.0 to 9.0 standard units	

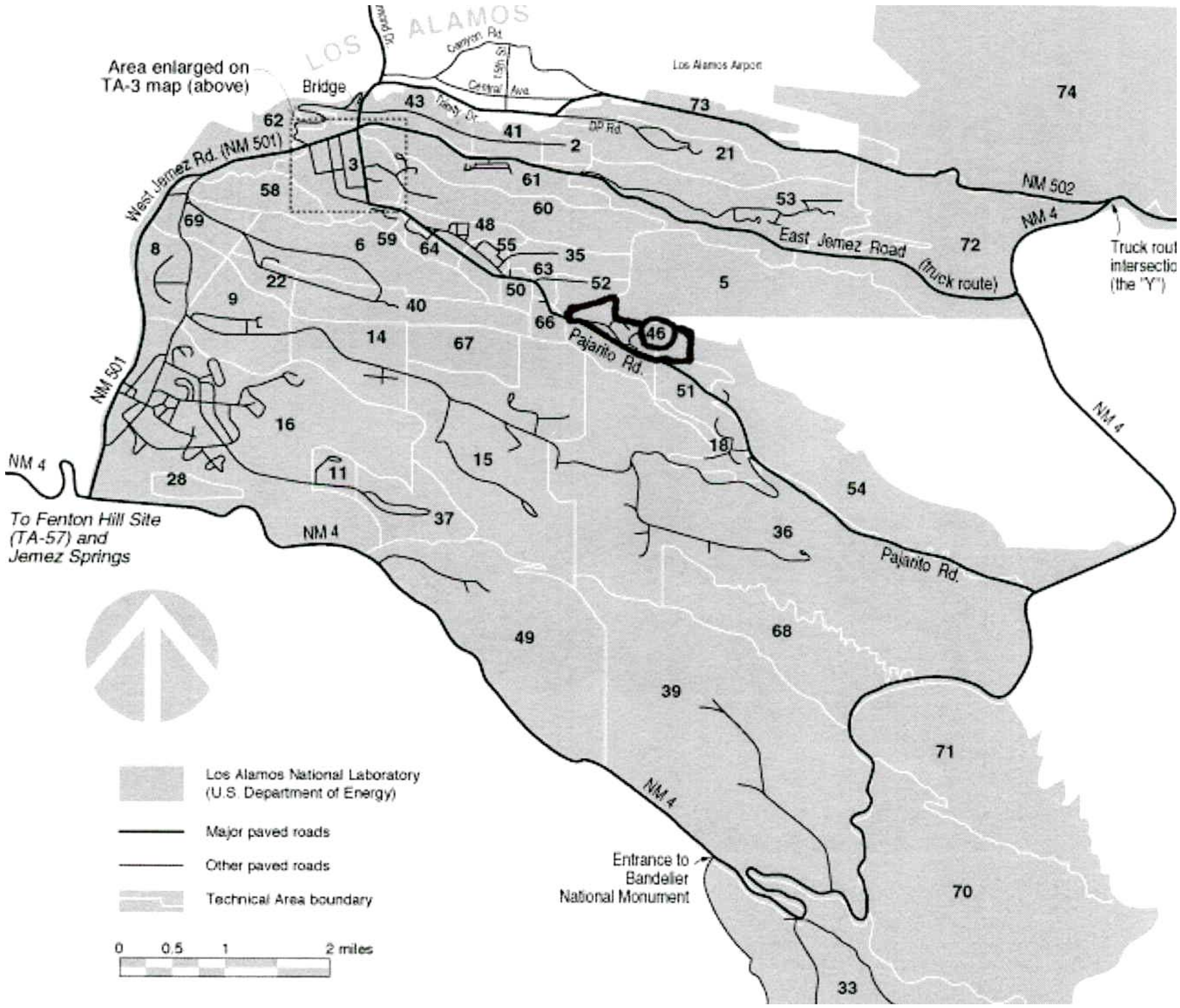


Figure 1. Location of Technical Area 46 and SWS

In addition, SWS is designed for nitrogen removal and is required by the State of New Mexico to limit total nitrogen discharged to groundwater through outfall 01A001 to <10 mg/L. Compliance testing for these parameters is performed by Johnson Control Northern New Mexico (JCNNM) Environmental and LANL.

Prior to 1992, there were 10 separate wastewater treatment sites and 9 different outfalls that were eliminated as part of an NPDES outfall reduction program. This change has resulted in the elimination of 8 sanitary outfalls and 32 septic tank systems (NPDES Permit No. NM0028344 fact sheet, 2/20/99). Treated sanitary wastewater is pumped to a reuse storage tank in TA-3 and then used for cooling water at the power plant, prior to discharge into Sandia Canyon through Outfall 01A001.

Construction of the SWS plant was completed in October 1992 at a project cost of $17.2 million. Funding was provided by an FY88 Construction Line Item with project construction management by ENG-1. The Treatment Plant and Collection System was designed by Molzen-Corbin and Associates of Albuquerque and construction was performed by Foley Company and Mingus Construction Company.

Operational Deficiencies

Although designed to treat 0.6 MGD, SWS rarely receives more than 0.3 MGD and, in some instances, less than 0.1 MGD. (Barnett, 7/14/00) Lack of sufficient flow into SWS, particularly on weekends and holidays, results in an inconsistent and often low biochemical oxygen demand (BOD). A shortage of organic material leads to routine operation weaknesses, particularly with respect to nitrification and denitrification. It also leaves SWS susceptible to serious repercussions from relatively small amounts of toxic influents. (Figures 2- 6).

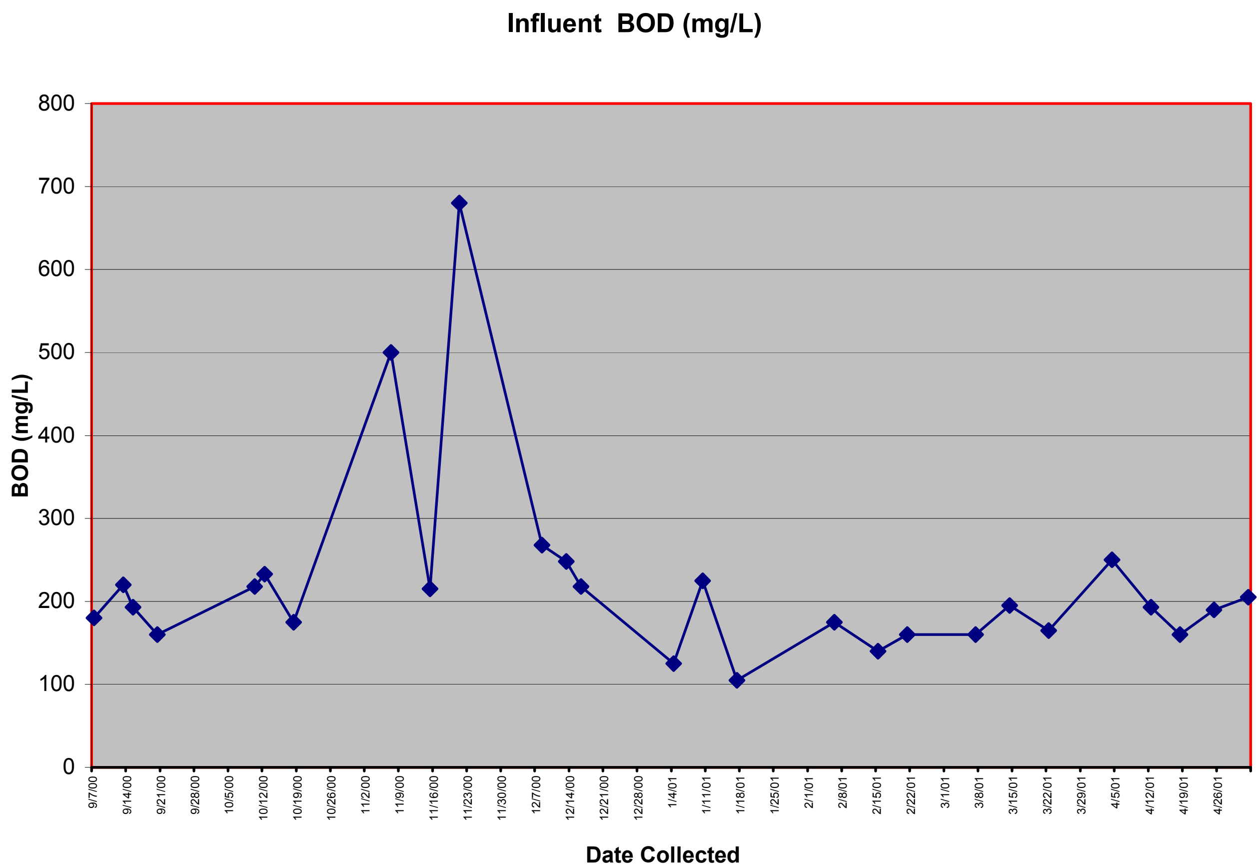


Figure 2. Graph of SWS Influent BOD (mg/L) between September 2000 and April 2001

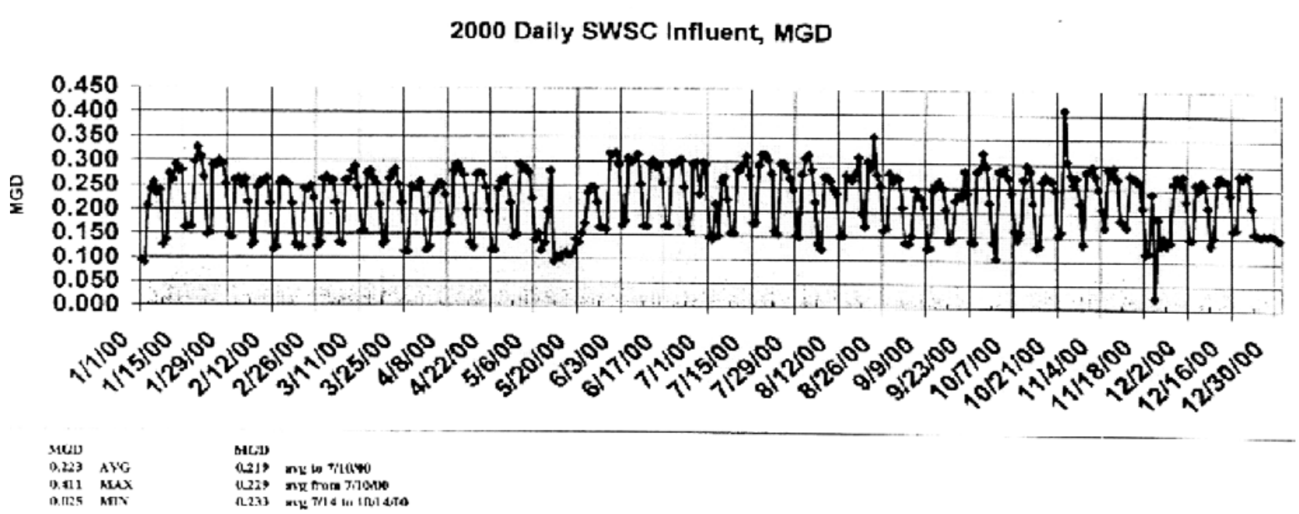


Figure 3. Daily Influent Flow (MGD) to SWS During 2000

2000	avg	max	min
Month	Influent, MGD	Influent, MGD	Influent, MGD
January	0.230	0.328	0.089
February	0.206	0.269	0.117
March	0.220	0.289	0.113
April	0.214	0.293	0.117
May	0.187	0.294	0.094
June	0.254	0.316	0.156
July	0.246	0.318	0.142
August	0.239	0.354	0.123
September	0.222	0.323	0.126
October	0.236	0.411	0.129
November	0.209	0.294	0.025
December	0.218	0.282	0.138
Annual	0.223	0.411	0.026

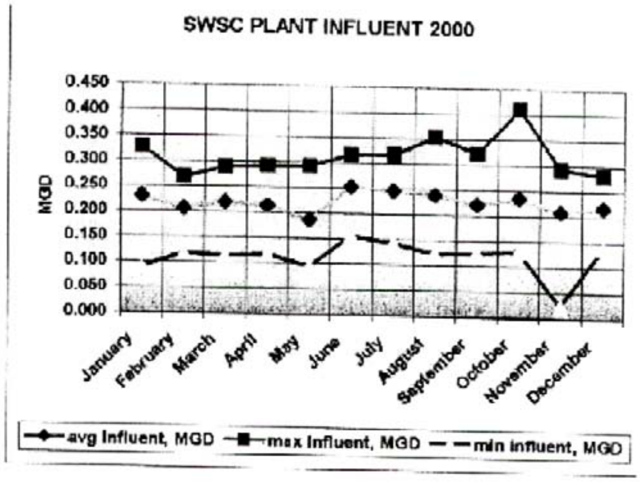
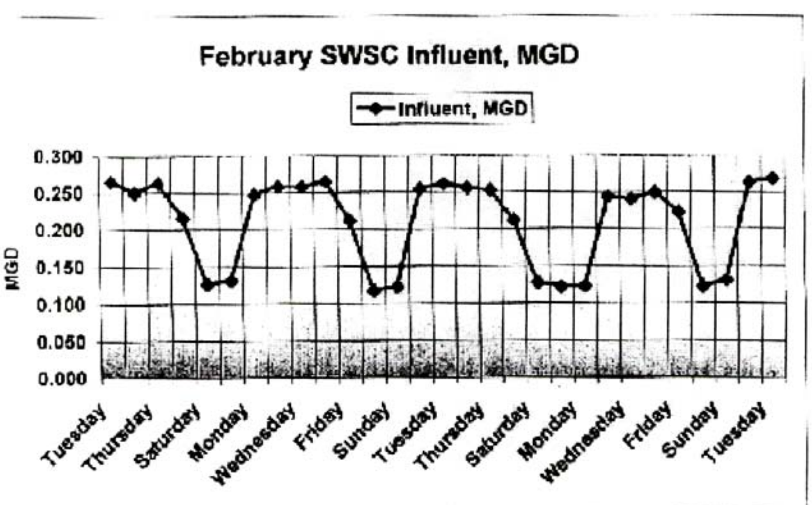
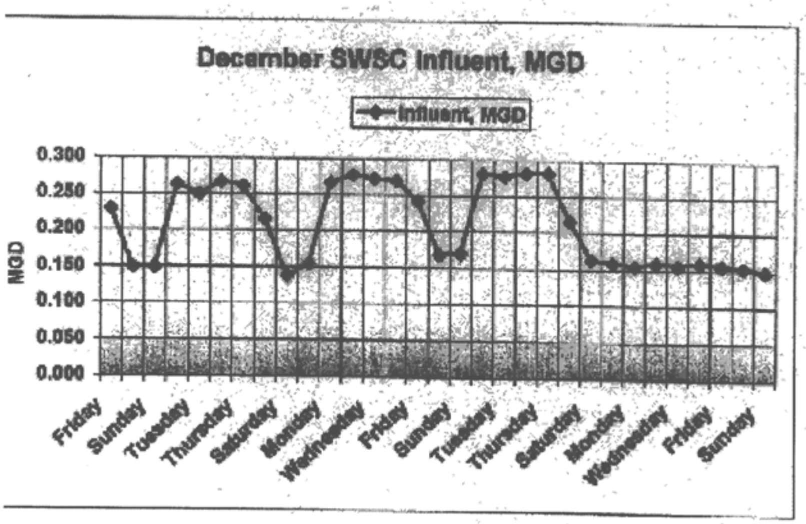


Figure 4. SWS Influent (MGD) During 2000: Minimum, Average, Maximum



Date		Influent, MGD
2/1/00	Tuesday	0.265
2/2/00	Wednesday	0.250
2/3/00	Thursday	0.263
2/4/00	Friday	0.215
2/5/00	Saturday	0.126
2/6/00	Sunday	0.131
2/7/00	Monday	0.247
2/8/00	Tuesday	0.258
2/9/00	Wednesday	0.258
2/10/00	Thursday	0.265
2/11/00	Friday	0.212
2/12/00	Saturday	0.117
2/13/00	Sunday	0.122
2/14/00	Monday	0.255
2/15/00	Tuesday	0.262
2/16/00	Wednesday	0.256
2/17/00	Thursday	0.253
2/18/00	Friday	0.212
2/19/00	Saturday	0.128
2/20/00	Sunday	0.122
2/21/00	Monday	0.123
2/22/00	Tuesday	0.243
2/23/00	Wednesday	0.240
2/24/00	Thursday	0.250
2/25/00	Friday	0.223
2/26/00	Saturday	0.123
2/27/00	Sunday	0.131
2/28/00	Monday	0.204
2/29/00	Tuesday	0.269

Figure 5. Pattern of Low Flow (MGD) on Weekends into SWS



Date		Influent, MGD
12/1/00	Friday	0.229
12/2/00	Saturday	0.150
12/3/00	Sunday	0.149
12/4/00	Monday	0.263
12/5/00	Tuesday	0.250
12/6/00	Wednesday	0.267
12/7/00	Thursday	0.261
12/8/00	Friday	0.215
12/9/00	Saturday	0.138
12/10/00	Sunday	0.155
12/11/00	Monday	0.287
12/12/00	Tuesday	0.278
12/13/00	Wednesday	0.272
12/14/00	Thursday	0.270
12/15/00	Friday	0.242
12/16/00	Saturday	0.168
12/17/00	Sunday	0.171
12/18/00	Monday	0.281
12/19/00	Tuesday	0.277
12/20/00	Wednesday	0.282
12/21/00	Thursday	0.282
12/22/00	Friday	0.216
12/23/00	Saturday	0.163
12/24/00	Sunday	0.159
12/25/00	Monday	0.165
12/26/00	Tuesday	0.159
12/27/00	Wednesday	0.157
12/28/00	Thursday	0.160
12/29/00	Friday	0.157
12/30/00	Saturday	0.154
12/31/00	Sunday	0.149

Figure 6. Holiday Flow (MGD) Pattern at SWS

Domestic wastewater treatment is dependent upon a biological process in which specific bacteria partially oxidize organic wastes (food source for the bacteria) to carbon dioxide, water, sulfate, nitrate, and other organic compounds. An unstable environment, caused by frequently changing conditions, (e.g. inconsistent food supply) will alter the metabolic processes of the bacteria resulting in incomplete degradation (stabilization) of organic wastes.

As a result of the outfall reduction program at LANL, approximately 26 industrial discharges were connected to the SWS collection system between 1995 and1997. The by-product of this program has been an increase in influent toxicity (Pulskamp, 1999). An occurrence report (LANL, 12/99) concerning an incident of low pH influent to SWS on July 14, 1998, notes that buffering capacity of SWS has remained constant while toxicity has increased annually by 3 percent.

The result of an inconsistent and low organic load, plus increasingly toxic influent, leaves SWS microorganisms vulnerable to acute or chronic toxicity. A single large toxic slug has the potential to kill microorganisms essential to biological treatment. Chronic toxicity can metabolically inhibit microorganisms, reducing treatment efficiency and effluent quality. Since SWS is the only sanitary wastewater treatment plant at LANL, the repercussions of a partial or total microbial kill could be substantial.

2.0 DESCRIPTION OF THE SEWAGE SYSTEMS AT LANL

SWS Activated Sludge Process

Wastewater is 99.99 percent water and .01 percent solids. Twenty percent of total solids from influent are suspended solids and will settle out by gravity. The other 80 percent of total solids is made up of dissolved and finely divided colloidal particles which require a biological treatment called activated sludge for removal. (Kerri, 1998)

The activated sludge process can be summarized in the following steps:

- Mixing the activated sludge with the wastewater to be treated (mixed liquor).
- Aeration of this mixed liquor for the required length of time (detention time).
- Separation of the activated sludge from the mixed liquor, in the final clarification process.
- Return of proper amount of activated sludge to the mixed liquor in the aeration basin.
- Disposal of the excess activated sludge (Blevins, 2001).

SWS uses extended aeration activated sludge. This is similar to a conventional activated sludge process, except that the organisms are retained longer in the aeration basins and there is a higher concentration of them, which means less food per bug. In addition to influent food, the microorganisms eat the stored food in the dead bugs returned from the clarifier. The new products are carbon dioxide, water, and a biologically inert residue. Extended air does not produce as much waste sludge as conventional activated sludge process (Kerri, 1998). Detention time (DT) for a microorganism traveling through the three SWS aerations is approximately 3 days (J. Ayers, SWS operator, personal communication, 5/15/01):

$$\text{SWS DT} = \frac{\text{Basin Size}}{\text{Average Daily Flow}} = 3 \text{ basins} \times .250 \text{ MG} = \frac{.750 \text{ MG}}{.250 \text{ MGD}} = 3 \text{ days or 72 hours} \qquad (1)$$

To control this process, it is necessary to control the growth of microorganisms and those factors that affect the microorganisms, of which 95 percent are bacteria. The amount of food present in the mixed liquor (a combination of wastewater and activated sludge) determines whether the bacteria will merely maintain their cell function or reproduce through cell division. Reproduction will only occur when there is excess food. When the number of bacteria has grown so large that the excess food is depleted, reproduction drops off and bacteria must compete for what is left. The bacteria lose their flagella, which allow them to pursue food, and are now covered with a sticky substance on the outside of the cell, which causes them to agglomerate into floc and settle out in the clarifier. Bacterial cells die, and the total number of living bacteria decreases. The bacteria that survive are now rested and ready to eat again. They are either returned from the bottom of the clarifier to the aeration basin as return activated sludge (RAS), where they become part of the mixed liquor or they are piped to the digester for eventual removal to the sludge beds. A schematic of the treatment process appears in Figure 7 (Glymph, T., 1997).

Influent Flow Through SWS System

Raw sewage as well as effluent from cooling towers enters SWS through one main pipe. The preliminary treatment occurs as influent passes through screens that eliminate rags, leaves, and large debris. These items are dumped into a hopper or barrel and transported to county landfill. After passing through the bar screen, the influent velocity slows and the weight of the sand and grit, too small to be caught by the screen, cause it to drop out. In the grit chamber, this process is assisted by pumping air into the influent so that the water molecules become lighter and the grit settles more easily (J. Ayers, SWS operator, personal communication, May 9, 2001).

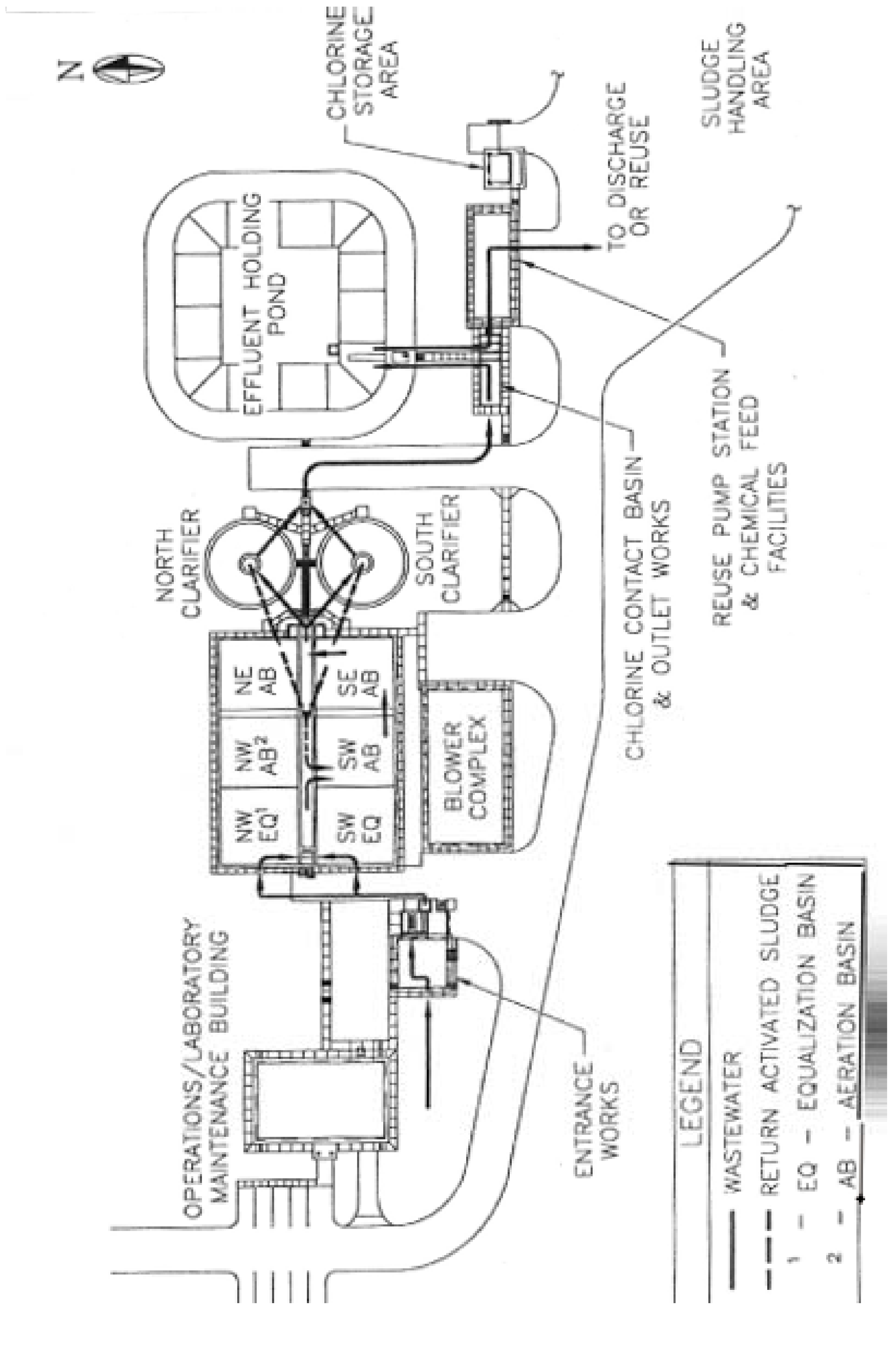


Figure 7. Schematic of TA-46 Sanitary Wastewater Treatment Facilities

Influent then flows into one or both of the equalization basins, where it is allowed to accumulate. This accumulation is then released in increments over each 24-hour period, in order to maintain an even flow into the aeration basins (Molzen-Corbin, 1993). Equalization basins are aerated to prevent accumulating influent from becoming anaerobic.

In the aeration basins, microorganisms contact and digest biodegradable materials (food); this is secondary treatment. Most digestion occurs in the aeration basin, although some digestion will occur in the clarifier. The aeration basins are linked to blowers that pump air continuously. This addition of air as well as the turbulence associated with it, add oxygen for metabolizing waste and keep microorganisms and suspended solids (waste) moving, allowing contact to be made continuously. This combination of microorganisms and food is called *mixed liquor* (glossary). The presence of oxygen in the aeration basin allows the nitrification process to begin. A discussion of the nitrification/denitrification process at SWS appears in Appendix A (p A-7).

The mixed liquor continues to the clarifiers where it is separated into supernatant and biological solids. The solids represent the colloidal and dissolved solids that were originally present in the wastewater. In the aeration unit they are incorporated into the activated sludge floc, and can now settle out in the clarifier. Some of the sludge that is removed from the clarifier will get wasted to the sludge holding tank, and this is called waste activated sludge (WAS). The RAS is essential to maintaining the volume of microorganisms needed to treat the influent. (When a new plant starts running it takes several months to build up a sufficient mass of activated sludge [Pulskamp, 1999]). The process of wasting allows the operator to maintain the proper balance of sludge as well as the desirable sludge age. Desirable sludge age is indicated by a good balance of microorganisms. This topic is discussed extensively in Chapter V.

In the sludge holding tank, the WAS continues to decompose until it is stabilized; sludge settles to the bottom and water rises to the top. This decanted water is returned to the aeration basin and the sludge blanket is piped to drying beds.

The most important function of the secondary clarifier is to maintain the wastewater quality produced by the preceding processes, so it is essential that the sludge in the clarifier be removed quickly, so that it does not become anaerobic and cause *rising sludge.* The cause of this phenomenon is denitrification (Appendix A: Wastewater Characteristics), in which the nitrites and nitrates in the wastewater are converted to nitrogen gas which bubbles up to the surface and escapes into the air. If enough nitrogen gas gets trapped inside the sludge at the bottom of the clarifier, the sludge mass becomes buoyant, rises to the top of clarifier and deteriorates effluent quality (Toprak, 2000).

As supernatant passes over the weir, grease and suspended solids that have gotten to this point are caught in a basket, which is manually cleaned. This clear water is now called effluent. Disinfection is accomplished in the chlorine contact basin using the MIOX process. A solution of brine (rock salt and water) is electrolyzed and added to the effluent (M. Talley, JCNNM, personal communication, 4/5/00). Chlorine is released producing chlorinated effluent, capable of killing pathogens. In the final step, effluent is piped to the power plant cooling tower.

Toxic Influent Scenarios

During normal SWS operations, two equalization basins, four aeration basins, and one clarifier contain a level of influent. A second clarifier is off-line and receives waste-activated sludge daily until sufficient accumulation requires the sludge to be piped to a drying bed.

In the event of a slug of toxic influent to SWS, operator strategy is to isolate the toxic influent to one of the two equalization basins. If a strong toxic flow is sustained for a long enough period, more basins will be contaminated. In this circumstance, the objective is to retain the largest uncontaminated population of microorganisms possible and, at the very least, to retain enough uncontaminated microorganisms to reseed (C. Barnett, SWS Plant, personal communication, 5/23/01). Reseeding is the process of growing a mass of microorganisms sufficient to treat normal wastewater volume, replacing destroyed population. Depending on how much damage is done to the microorganism population, reseeding could take 2 to 8 weeks for full recovery. (Pulskamp, 1999) A shutdown of SWS could temporarily shut down LANL until wastewater could again be treated. Any day that LANL is shut down represents a loss of $4 million, the daily cost of labor (Herring, 2001). The daily cost of being out of compliance for all NPDES parameters could be as much as $100,000 per day (Barnett, 7/14/00)

Two occurrences of damaging toxic influent to SWS on July 11, 1998, and again on August 30, 1999, are documented and discussed briefly in Chapter 3.0.

3.0 LITERATURE REVIEW

The first five references specifically document SWS operations, the problem of low organic load and increasing influent toxicity. Reference six is a feasibility study by Jacobs Engineering, Inc. and reference seven (Watts, 1996) discusses solutions to industrial WWTPs with inconsistent BOD.

Molzen-Corbin & Associates (1993)

The first quarter of project performance, SWS facility was not completely finished. The second quarter performance analysis is affected by lack of certain quantitative data (pH, influent color, high temperatures and irregular flow) the result of equipment not yet operational. During the third quarter, pH is trended continuously and COD analysis is performed. This report concluded that:

a) 'Spikes' in temperature and pH during the second quarter were the result of non-domestic discharges in the SWS collection system although lack of certain data prevents any firm conclusion for the second quarter.

b) Approximately 2,000 lbs. of dog food must be used during the ten days of Christmas break to supplement biochemical oxygen demand to maintain a food source of one-half the loading concentration experienced during normal weekly operation.

c) It is determined by Molzen-Corbin Inc. that a mixed liquor suspended solids of 2,000 mg/L is optimal for best BOD and TSS removal during mid-winter.

d) It is determined through operator trial and error that dissolved oxygen no greater than 1.0 mg/L will nitrify all ammonia and allow oxygen to drop quickly to "0" when aeration is discontinued. Aeration must be "off" only as long as necessary for nitrate removal, so that effluent BOD and TSS concentrations do not increase.

LANL (1997)

On 4/2/97, the Water Quality and Hydrology staff (ESH-18) verified that a sample taken on 3/20/97 from Outfall 3S, had a BOD of 73 mg/L, significantly higher than the NPDES BOD limit of 45 mg/L. The MIOX disinfection pilot program was taken off line and carefully screened but occurrence investigation did not uncover root cause of exceedance and MIOX program was put back on-line.

Pulskamp (1999)

This report found increased influent toxicity directly related to the increased number of industrial discharges that were transferred to the SWS collection system in order to decrease the number of NPDES outfalls at LANL.

Between 1995 and 1997, 26 industrial discharges were connected to the sanitary waste collection system. A comparison of 288 discrete influent samples taken between February, 1995 and December, 1998 revealed an increase in toxicity of 72 percent over those three years, based on Microtox analysis. Microtoxicity is determined by the light output from luminescent bacteria added to an influent sample and then compared to a control sample. A reduction of greater than 50 percent of light output is considered toxic.

Microtox analysis monitoring was implemented by Johnson Controls Northern New Mexico Environmental Protection Group (HENV) in response to toxic spikes from industrial discharges of acids, bases, oil, paints, large quantities of salt and other toxic substances. Baseline values were established and microtox waste acceptance criteria was added to LANL's Waste Profile Form, January 1996.

Instances of atypically high effluent BOD results suggest that increased toxicity of discharges inhibited metabolism of microorganisms in aeration basin.

Two types of toxicity are possible: acute and chronic. Acute toxicity is the result of one or more slugs of toxic material in a short period of time that kill some or all of the microorganisms. Chronic toxicity is the product of microorganisms dying or being metabolically inhibited over a long period of time. In either case, toxicity combined with erratic changes in wastewater composition, can reduce the population of microorganisms resulting in less capacity for BOD removal and deteriorated effluent quality.

LANL (7/7/99)

On 7/11/98, SWS received an abnormal influent with a pH range of 4.0 to 4.5 and an elevated concentration of ammonia nitrogen for a 2.5-hour period. The operator on duty at SWS was alerted by the pH alarm and diverted the abnormal influent to an equalization basin before it entered the aeration basin and damaged biological units. Based on chemical toxicity and sustained volume, the occurrence investigator estimated the impact could have caused NPDES non-compliance and fines of up to $100,000 per day. This incident could have had major impacts to the SWS biological systems to the point of causing full or partial shutdown of SWS for an estimated two to four weeks.

The cause of this was subsequently determined to be the result of a maintenance procedure on a cooling tower heat exchanger in which silica scale is removed with hydrochloric acid and ammonium-bifluoride (ABF) at a pH of 1-1.5. It was concluded that the mechanical seal on the chemical treatment circulation pump failed, allowing low pH water to exit from the tank and co-mingle with the potable water that cools the pump. The co-mingled liquids were then released into an area floor drain that connects to SWS. JCNNM estimated that the volume of co-mingled water/acid released was 40 gallons/minute for 2.5 hours. In addition, arsenic contamination was discovered in the wastewater and traced to the manufacturing process of the ABF. A new source for ABF was found and all stock with arsenic contamination returned.

The direct cause of this incident was personnel error in failing to follow established procedures. All waste streams discharged to Sanitary Waste Collection System must be containerized and characterized prior to discharge in order to ascertain that waste streams meet the SWS waste acceptance criteria (WAC). Additional safeguards were put in place to maintain a closed loop system for cooling tower maintenance discharge water prior to release.

The significance of this occurrence with regard to present project is that chemicals toxic to activated sludge are used regularly at LANL in a variety of ways and since human error can never be completely eliminated, the potential for damage to SWS microorganisms and Laboratory operation, does exist.

LANL (12/9/99)

On 8/30/99, SWS received an abnormal green influent that was highly toxic and caused a kill-off of a portion of the plant's free-swimming ciliates, reducing the plant's ability to treat wastewater. A sample of the green influent was analyzed and found to have a high Chemical Oxygen Demand (970 mg/L) and a very high toxicity of 97 percent. SWS WAC criteria include a COD that is not greater than 500 mg/L and a toxicity level that is not greater than 50 percent. The investigation was unable to determine the source, or the precise chemical constituent(s).

This incident had the potential to adversely affect the SWS operation for an estimated 2 to 8 weeks for full recovery of microorganisms, while incurring fines of up to $100,000 per day. One of the corrective actions took place on October 26, 1999, when SWS and Los Alamos County (LAC) personnel met to determine the feasibility of SWS receiving a portion of LAC influent to increase the plant's organic load and buffering capacity.

Jacobs Engineering (2001)

Cost estimates for design build as well as for total project were itemized for diversion of LAC influent into LANL's sanitary waste system. Total cost of project was estimated to be $950,000. A fuller discussion of the process that led to study results appears in Chapter IV on Methodology. Feasibility study is reproduced in Appendix B.

Watts (1996)

Watts notes that "low-loaded plants are notorious for poor settling sludge and that expecting a treatment facility to handle a very wide range of loads is asking for trouble."

A respirometer is suggested as a solution to the problem of influent that is variable in strength and toxic content. This on-line device assesses the load of incoming waste and quantifies potential toxicity, prompting diversion to another tank when appropriate; contents can be reintroduced to waste stream in a more dilute form. This equipment will not take care of a situation in which concentration and load are suspected of chronic weakening of biomass without being identifiable as toxic.

4.0 COST-BENEFIT METHODOLOGY

Theory of Benefit-Cost Analysis (BCA)

Benefit-cost analysis (BCA) is a technique for evaluating a project or investment by comparing the economic benefits with the economic costs of the activity. Benefit-cost analysis has several objectives. As a method BCA can be used to evaluate: 1) economic merit of a project, 2) competing projects, 3) business decisions, 4) worth of public investments, 5) the wisdom of using natural resources or altering environmental conditions. Such a definition takes BCA beyond economic advantage to consideration of social welfare. (Shively)

Regardless of the aim, all benefit-cost analyses have several properties in common. A BCA begins with a problem to be solved. Various approaches to solving the particular problem are considered. The costs and benefits of these projects are identified, calculated, and compared, including a 'do nothing' option. (Shively)

BCA is a valuable tool for decision-making. It is most useful because it provides a starting point from which to begin evaluation of a project. BCA forces project advocates and opponents to provide quantitative data to back up qualitative arguments. While BCA may not include all the criteria deemed important in an evaluation, it does allow interested parties to clearly define the issues involved. (Shively)

While BCA can be useful, there are some difficulties with its application. First, it requires that the analyst assign monetary values to all benefits and costs, not readily done in the case of an intangible benefit such as improved fish habitat or other environmental values. The most significant drawback with BCA is that results hinge on the choice of the discount rate. Higher interest rates will lead to fewer projects presenting positive net present values than lower ones. Persons favoring more government investment argue for lower rates and those favoring less argue for higher rates. (National Center). The Office of Management and Budget (OMB, 2000) nominal discount rate for a 20-year project is 6.2 percent, a combination of the real discount rate of 4.1 percent (OMB, 2000) + an inflation factor of 2.1 percent.

Discounting is a technique that converts all benefits and costs into their value in the present. Discounting is based on the premise that a dollar received today is worth more than a dollar received in the future. This bias toward the present arises because by placing a dollar in a safe investment today, you can increase its value to more than a dollar tomorrow. Another way of saying this is that a dollar received in the future is not worth as much as that same dollar received in the present. That is, the future value of the dollar is discounted (Shively).

Benefit-Cost Analysis Applied to Influent Diversion Project

In March 2000 a Design Charrette convened to debate the merit of this project and decide whether or not to continue. Five separate routes for diverting LA County influent into the SWS system were analyzed. It became clear that one route is superior to all others, based on projected costs, pump hydraulics and environmental factors.

Jacobs Engineering Inc. was contracted October 3, 2000 to do a feasibility study on selected route for influent transit, including a cost proposal, a report on the analysis of affected existing town site sanitary sewerage system, lift station capacity (#43-10), proposed new sanitary structures, preliminary hydraulic calculations, layout drawing and environmental factors (Appendix B).

On February 26, 2001 a draft proposal was submitted to the team (Appendix B, p4) by Jacobs Engineering, Inc. Two options were proposed and cost estimated. Both options begin at a proposed lift station near a manhole tie-in at the northeast corner of Diamond Drive and Canyon Road and proceed south on 39th street and across Trinity. At this point option A1 continues south to tie-in with an existing 6” cast iron line that connects to LANL Sanitary Waste Collection System. Option A2 veers west and connects to an abandoned 4” cast iron line that connects with LANL SWS. The costs of options A1 and A2 respectively are $188,563 and $197,750. A1 is more direct, slightly cheaper, and does not require excavating the busy area adjacent to Los Alamos Medical Center. Option 2 has more favorable pump hydraulics to enable increased future flows, however both existing lift stations are fully capable of handling the projected load.

Team members from LANL, DOE and LAC reviewed draft and decided cost estimates were unrealistically low. On March 15, the team chose option A1 and Jacobs engineering redid the cost estimate. The new costs were delivered on May 3, 2001.

In addition to the design build and construction estimates is the cost of an environmental impact (EIS) statement to be done at LANL by Environment Safety & Health (ESH-20), the ecology group. Before doing an EIS, a one-page NEPA review is done. This is a brief summary of the environmental issues posed by the implementation of this project as well as a forecast of a positive or negative outcome for the EIS. The one-page summary is based to a great extent on the results of the LANL ESH-ID process. This formal process allows the project to be reviewed by subject matter experts who give feedback on environmental impacts of the project, as well as the compliance and safety regulations that must be met.

The process continued with identification of project benefits, including intangible benefits that could not be converted to a dollar amount easily, e.g. good public relations in the greater community of Northern New Mexico. Wherever possible, benefits were converted to dollar amounts, and compared with the dollar costs of capital investment, design processes and ESH requirements. The qualitative value of intangible benefits was included for consideration, e.g. a margin of conserved water for future project development, the risk of a partial-to-total

LANL shutdown (documented at greater than $4,000,000 per day). Benefits are discounted by year so that dollar amounts can be compared in present dollar value.

5.0 BENEFITS OF ADDING INFLUENT TO SWS PLANT

More Reliable Operation During Holidays and Weekends

Increased Organic Load

The organic food supply is composed of two variables: 1) flow amount in millions of gallons per day and 2) biochemical oxygen demand (BOD) in mg/L. (A discussion of BOD appears in Appendix A. The SWS at LANL has very low BOD influent after work hours as well as on weekends and almost none on holidays. Weekend flow is approximately 50 percent of mid-week flow, and is almost exclusively cooling tower water with no organics (Barnett, 1/25/00). Currently, SWS operators compensate for low organic load nights and weekends by retaining influent in the equalization basin and releasing it in increments between Friday and Monday (LANL, 1993). An example of the SWS influent BOD might be:

- Monday-Thursday: 438 pounds of BOD/day
- Friday-Monday: 125 pounds of BOD/day

By using the equalization basins to retain flow for release during the weekend, the difference in pounds of BOD between mid-week and weekend is somewhat diminished, but there is still a significant difference, which might be:

- Monday-Thursday: 338 pounds of BOD/day
- Friday-Monday: 225 pounds of BOD/day

In this example, microorganisms will have approximately one-third less to eat Friday, Saturday, and Sunday, even with this accommodation. With decreased food on weekends for the same population of microorganisms, reproduction will decline, old microorganisms will starve and diversity will be reduced, leaving microorganisms that can best compete for food (e.g., filamentous would out compete many bacteria) which would be an undesirable consequence.

During protracted holidays such as Thanksgiving and especially Christmas when LANL shuts down for 10 days, this procedure is inadequate, and 250 pounds of dog food is added daily. Although dog food helps, it does not contain ammonia to feed the nitrifying bacteria and the activity level of microorganisms is slowed, while they acclimate to this new food environment (Ayers, 5/6/01).

To achieve a consistent medium strength wastewater continuously at SWS, organic waste from LAC influent will be diverted to SWS. This added influent will result in a more consistent food supply and a better fed, healthier population of microorganisms capable of buffering toxic spikes more easily. The added flow will also contribute to buffering through dilution (Barnett, 3/3/00). Table 2 shows Los Alamos County Bayo WWTP plant influent for 8 months of 2000. By comparing Table 2 (1999) with Figure 2, it can be seen that the LAC plant has a narrower, more consistent BOD range than SWS. Table 3 shows the average monthly and annual influent BOD in the Bayo plant during 1999 with an annual average of 212 mg/L. Notice that the COD during both years is below the COD SWS WAC of 750 mg/L.

In calculating the volume of flow to divert from LAC, the objective is to maintain a steady organic load into SWS, seven days per week**.** There will probably be two settings to accomplish this, a mid-week setting and a higher weekend setting; a raised or lowered weir at the point of diversion will allow this to happen easily (Barnett, 1/25/00). To accommodate County needs, peak flows that occur twice a day at approximately 10 am and 7 pm will be shaved and diverted to LANL, and the SWS equalization basins will still be used to release a consistent flow to the aeration basins (T. Glasco, LAC Water Director, Personal Communication, 3/15/01)

Table 2. LAC Bayo Treatment Plant Monthly Data (2000) Including Flow (MGD), BOD (mg/L), COD (mg/L), TSS (mg/L), TKN, and pH

Month	MGD Total Q Inf.	BOD mg/L	COD mg/L	TSS mg/L	TKN	pH	Temp (C)
January	29.16	149	489	217	x	x	x
February	26.95	129	584	518	55.0	7.55	15.7
March	29.99	201	615	253	47.5	7.70	15.7
April	28.91	159	405	137	37.5	7.16	19.0
May	28.64	134	528	246	37.5	7.22	22.4
June	30.17	101	612	335	61.3	7.11	23.1
July	29.62	159	434	297	26.5	7.64	24.2
August	30.62	165	479	288	23.1	x	x
September			676	229	x	x	x
October							
November							
December							

Courtesy: LAC Bayo Plant

Table 3. LAC Bayo Treatment Plant Monthly Data (1999) Including BOD (mg/L), COD (mg/L), and TSS (mg/L)

Month	BOD mg/L	COD mg/L	TSS mg/L
January	255	650	220
February	205	493	226
March	226	460	198
April	223	485	217
May	217	549	206
June	315	698	357
July	195	492	244
August	208	542	267
September	208	461	262
October	139	527	248
November	147	467	198
December	204	572	248
Average	212	533	241

Courtesy: LAC Bayo Plant

Younger Sludge in Winter (Because of Higher BOD)

Sludge age is defined as the average time in days suspended solids remain in the system. Calculating sludge age is done using Equation (2) (from Kerri, 1998):

$$\text{Sludge age in days} = \frac{\text{Pounds of mixed liquor suspended solids in aeration basins}}{\text{Pounds per day of influent suspended solids}} \tag{2}$$

Sludge age is adjusted up and down throughout the year to accommodate seasonal variations. Extended aeration activated sludge plants usually have an age range between 15 and 30 days (Kerri, 1998). At SWS, sludge age is approximately 30 days during summer and 50-55 days during winter (Ayers, 4/11/01). This high winter number is the result of the need to build solids by wasting less, in order to compensate for the reduction in microorganism activity caused by the drop in temperature. However, build-up of solids leads to old sludge that produces lower quality effluent (i.e., too much filamentous bacteria). In the summer time, biological activity increases, and a smaller population of microorganisms is adequate to treat the same amount of waste. Figure 8 shows old sludge has more strands of filamentous and more rotifers than either the young sludge or optimal-age ('right') sludge.

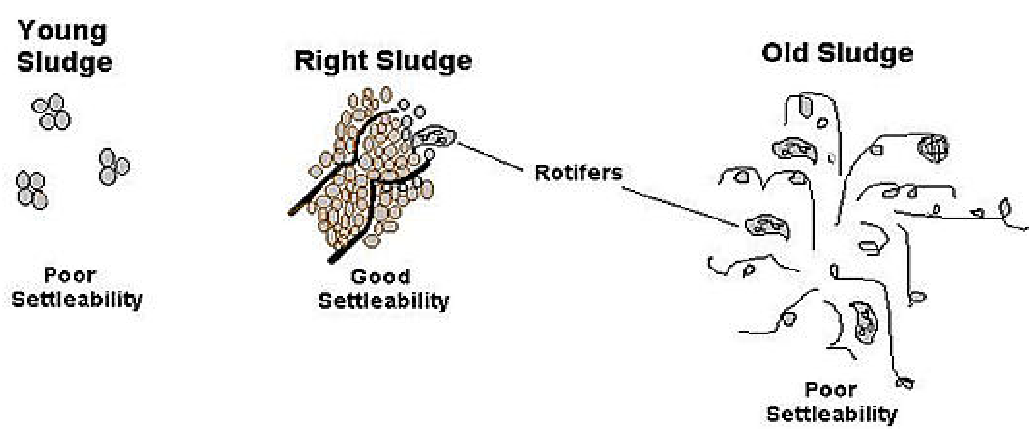


Figure 8. Different Appearance of Sludge Depending on Age

Having more organics coming into SWS through LAC influent will allow operators to maintain a somewhat younger sludge during cold weather since the microorganism mass will be augmented. Lower sludge ages normally produce a higher quality effluent.

Warmer Influent Added

Biochemical reactions are often very temperature dependent. Each 10 °C drop in temperature commonly results in a microorganism activity decrease of 50 percent (George, R 2001). During Thanksgiving and Christmas, the weakening effect of low flow and low BOD on the treatment process is compounded by low temperatures.

LAC influent has a higher temperature than SWS influent, because it has a greater organic load and because it flows 24 hours per day (George, 2000). Because SWS must hold a percentage of flow in the equalization basins for release during the weekend, this influent sits in the equalization basins and mixes with the cold air temperature at the surface of the water. During the winter the water temperature in the aeration basin can be as low as 7° C. The microorganisms will be less active at this temperature. By adding LAC influent, a higher temperature can be maintained during the winter when most problems occur, because 1) LAC influent has a higher temperature than SWS influent and 2) the larger combined biomass will generate more heat.

Less Vulnerability to Toxic Influents

More Robust Influent

Additional organic load will significantly improve the buffering capacity of the bugs to resist toxic influents such as a solvent or a high pH. The increased flow volume from LAC will dilute whatever comes through SWS (Barnett, 3/30/00). "The SWS plant has a history of spikes of influent toxicity resulting from discharges of industrial wastewater to the sanitary sewer system. These ‘off normal’ discharges consist of acids, bases, oils, paints and toxic substances” (Pulskamp, 1999, p6).

As of 1999**,** waste streams into SWS have been required to pass a Waste Acceptance Criteria (WAC) similar to the criteria used by many municipalities for sanitary influent; the WAC details what SWS will accept and in what concentrations.

The WAC does not require a BOD because this test takes 5 days and there may be a need to dispose of waste liquid more quickly. Instead a chemical oxygen demand (COD) limit of 750 mg/L is established. The COD is known to be approximately 2 to 3 times the BOD, and a COD test can be done very quickly (Appendix D contains the LANL Waste Acceptance Criteria for sanitary liquid waste). It has taken some time for Technical Areas to comply with the WAC, but those that still do not are being tracked to eliminate the practice of “dumping” liquids that can damage the microorganism population and it’s ability to metabolize waste.

By increasing the robustness of the mixed liquor, the criteria for accepting waste streams can be relaxed and influents that have not been acceptable, might *become* acceptable (Barnett, 5/1/01). For example, a product to strip floor wax that does not meet the current WAC, might become acceptable. This in turn would reduce the costly “special waste” that LANL must send off site for treatment. These added waste streams also contribute water for reuse.

> In February 2000, Facility Management Unit (FMU) 77 had been charged $6500 for disposal of 3 drums of floor mopping wastewater, which by all accounts was regarded as non-radioactively contaminated, non-hazardous, and non-regulated. However, it did not pass Waste Acceptance Criteria (WAC) for the Sanitary Waste System Consolidation (SWSC) facility at TA-46 and, therefore, was managed as a special waste

> through the Solid Waste Facility, FWO-SWO, at TA-54. The RAGGMOPP Project team was created in April 2000 to investigate the causes and develop solutions for the high disposal cost of custodial wastewater in FY00.
>
> One of the solutions that emerged was the identification of two products (Franklin Once-Over Wax Stripper and Franklin Carpet Extraction Cleaner) by Kleen-Tech at specified dilutions, which have been determined to be acceptable for disposal through the sanitary sewer system.
>
> However, the cleaning products for industrial no-wax flooring and low maintenance carpet do not pass the current SWS WAC. These should be retested against any revisions to the WAC following completion of the connection to the Western Area. If the wastewater from such products can be disposed of through the sanitary sewer system, the ease of use should result in lessened labor costs for cleaning." (Mahoney, 2001, p. 1)

Domestic Influent Added

Residential influent does not usually have the kind of problems associated with industrial influent, which can cover a broad spectrum of concentrated toxic wastes. Although LANL cooling towers do release some chemicals and brine from backwashing, it is not classified as industrial**.** It is equally significant that cooling tower effluent does not contain organic waste and dilutes the relatively sparse organic load that flows out of Laboratory bathrooms and cafeteria (Pulskamp, 1999).

The northern and western quadrants of LAC are almost entirely residential and will supply a steady stream of domestic waste 365 days a year. Although there could be some toxic solvents from household cleaners in LAC influent, the expectation is that the amount of toxic would be miniscule compared to the total influent waste stream and should be sufficiently diluted to be innocuous (Barnett, 3/30/00). In addition, LAC has created an annual Household Hazardous Waste Day when residents can put out accumulated household chemicals for pick up by the County (Sisneros, 1999) which will reduce hazardous household waste in LAC influent. Ammunition is handled by the local police department and a swap table of items like paint and thinner, is available to anyone.

The primary criteria for evaluating sludge disposal is the EPA's 40 CFR, Part 503 regulations for the land application of sanitary sludge. The regulations evaluate the extent of treatment the sludge receives which determines pathogen content and whether it can be land applied, or distributed and reused. Los Alamos County has a Class A rating because the sludge is composted at specific time and temperature which allows LAC to dispense it to the public for fertilizer, an indication that it is considered harmless. SWS does not land apply its dried sludge, so there is no need for an A/B rating. SWS sends dried sludge to TA-54 and from there it goes to a sanitary landfill, permitted for sludge (Barnett, 7/31/01).

Improved Water Quality

Increased Organic Load

Microorganisms require certain organic materials for growth. The basic nutrients of abundance in normal raw sewage are carbon (C), nitrogen (N), phosphorus (P), with the ratio of C:N:P approximately equal to 100:10:1. In addition to C, N, and P, trace amounts of Sodium (Na), Potassium (K), Magnesium (Mg), and Iron (Fe) are present. In normal municipal sewage, most of these nutrients are provided (Glymph, T., 1997).

When proper nutrients are not available, activated sludge metabolism fails and a kind of "bacterial slime" accumulates around cells. Cells slow down in activity because they cannot produce enough enzymes and because needed nutrients cannot penetrate the slime layer as they should. Sludge will not settle and BOD removal slows down (Glymph, T., 1997).

Improved Flocculation

A floc is composed of organic matter surrounded by bacteria; activated sludge is an aggregation of floc particles. Activated sludge is capable of sorbing or adsorbing colloidal and dissolved organic matter. The biological organisms utilize the absorbed material as food and convert it to inert insoluble solids and new bacterial cells. Much of this conversion is a step-by-step process. Some bacteria attack the original complex substances producing simpler compounds as waste products, which are used by other bacteria to produce still simpler compounds. The process continues until the final waste products can no longer be used as food for bacteria (Glymph, T, 1997).

Filamentous bacteria can grow inside and outside the floc. A certain amount will help stabilize and strengthen the floc, but when there is too much filamentous growth, a very dispersed web is formed by strands that link the floc and prevent settling. Nutrient deficiency encourages the growth of Nocardia, a type of branching filamentous that adversely affects settling, and effluent quality. (Filamentous, 1990)

As bacteria begin growing, they generally develop into small chains or clumps. They are very motile, and it is difficult for them to settle. They have not yet developed the slime layer, which aids them to stick together. When mixing occurs, the small chains or clumps are broken up and the microorganisms are dispersed, and will not flocculate or settle. As the sludge is allowed to age, the microorganisms lose their motility and accumulate more slime. Clumps and chains are better able to stick together. The clumps grow bigger and bigger until they form a floc. If the organisms are allowed to develop properly under the right conditions, the flocs get large and compact and begin to settle. Mixing in the aeration tank tends to keep the floc small since even though the microorganisms are sticky, the bond formed holding the organisms together is not very strong. This is good because it allows the cells access to food and oxygen (Glymph, T, 1997).

Increased Organism Diversity

Under good conditions including sufficient organic load, a diversity of organisms will be present (Figure 9) (Barnett, 6/13/00).

<u>Protozoa</u>

The presence of protozoa is related to effluent quality and plant performance. Protozoa play a secondary but important role in purification of aerobic wastewater. In general, protozoa grow best in ambient temperatures of 15-25 °C, are extremely pH sensitive, and, like bacteria, must have sufficient dissolved oxygen to survive. The protozoa in the activated sludge treatment process fall into three major classes: amoebae, flagellates, and ciliates.

Amoebae. Amoebae are the most primitive, single-celled protozoa. They are frequently present in raw influent, but are short-lived in the aeration basin. Amoebae can only multiply when there is an abundance of nutrients in the aeration tank. Because they are pseudopods, they move very slowly, so it is difficult for them to compete for food when there is a limited amount available. They are dominant in the aeration basin for a short time.

Flagellates. Most flagellates absorb dissolved nutrients soon after amoebae begin to disappear and while there is still high concentrations of soluble food. Flagellates and bacteria both feed on organic nutrients in the sewage; as the nutrient level declines they have difficulty out-competing the bacteria for soluble food and their numbers begin to decrease. Large numbers of flagellates present in the later stages of activated sludge

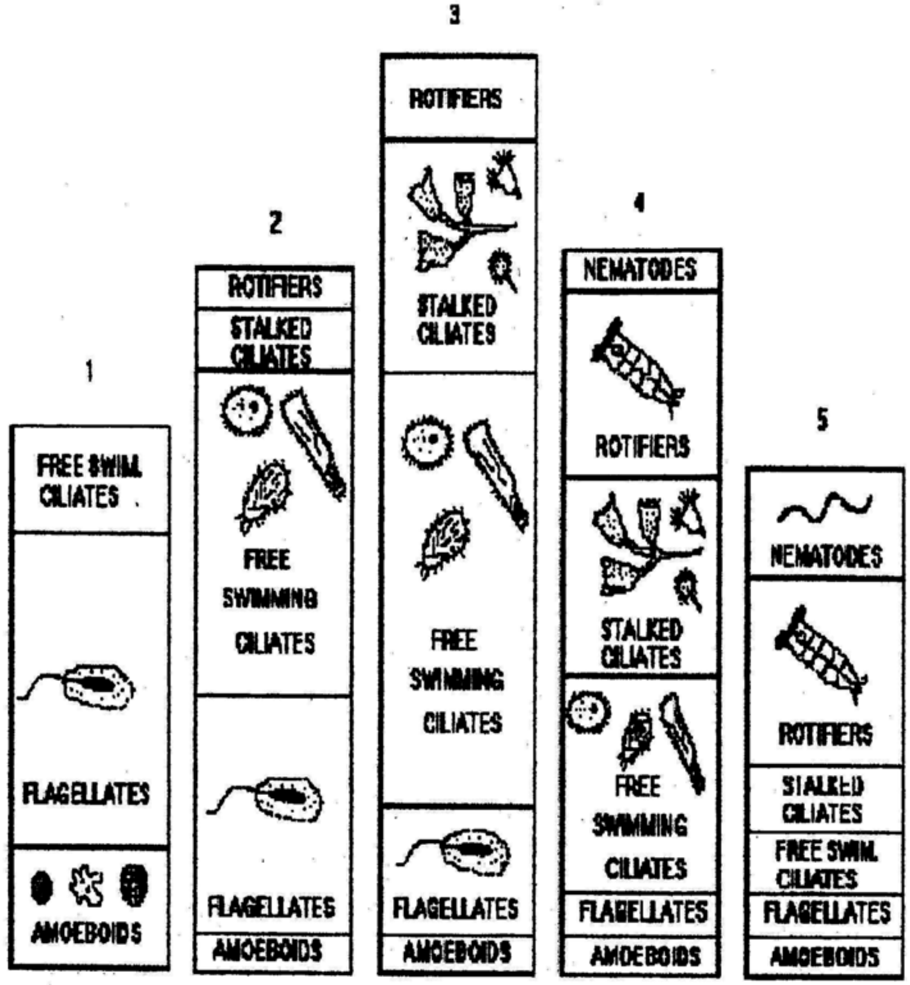


Figure 9. Organism Diversity and Age in Mixed Liquor

development usually indicate wastewater that still contains a large amount of soluble organic nutrients.

Ciliates. Ciliates feed on bacteria, not on dissolved organics. While bacteria and flagellates compete for dissolved nutrients, ciliates compete with other ciliates and rotifers for bacteria. The presence of ciliates indicates a good sludge, because they dominate after the floc has been formed and after most of the organic nutrients have been removed.

Rotifers

Rotifers are rarely found in large numbers in wastewater treatment processes. The principal role of rotifers is the removal of bacteria and the development of floc. Rotifers contribute to the removal of effluent turbidity by removing non-flocculated bacteria. Mucous secreted by rotifers at either the mouth opening or the foot aids in floc formation. Rotifers require a longer time to become established in the treatment process. Rotifers indicate increasing stabilization of organic wastes, although too many rotifers indicate an aging sludge.

Fungi

Fungi are relatively rare in activated sludge. When present, most of the fungi tend to be of the filamentous forms, which prevent good floc formation, and, therefore, decrease the efficiency of the plant. A high carbohydrate waste, unusual organic compounds, low pH, low dissolved oxygen concentrations, and nutrient deficiencies stimulate fungal growths. The other forms of microorganisms present in activated sludge play a minor role in the actual stabilization of the organics in wastewater (Glymph, T., 1997).

6.0 COST-BENEFIT ANALYSIS

Costs/benefits of this project fall into three categories:

- Environmental
- Economic
- Intangible

Los Alamos National Laboratory

Environmental Benefits

Greening the Government through Energy Efficiency Management (1999) mandates the development of water performance goals in government agencies. The U.S. Department of Energy is committed to not increasing the number of AFY used at LANL. Effluent generated by this diversion project can replace 200,000 GPD of potable water in cooling towers or can be used to irrigate lawns, suppress dust at construction sites, or for manufacturing processes that do not require a high level of purity. A pie chart of water allocation in 1997 (Figure 10) (LANL, 2000) shows 58 percent of LANL water flowing into cooling towers, a percentage that will increase without conservation. Based on continued use of 1498 AFY, with projected conservation of 223 AFY, cooling tower use drops from 58 percent to 43 percent of the Laboratory's total annual consumption.

Figure 11 depicts projected water usage in LANL cooling towers from FY '00 to FY '05 without conservation. The new Super Computing Complex (SCC) is expected to use more than 100 AFY in its cooling tower in FY '02 and then increase. Figure 12 graphs total water usage from FY '91-FY '05 for four different scenarios:

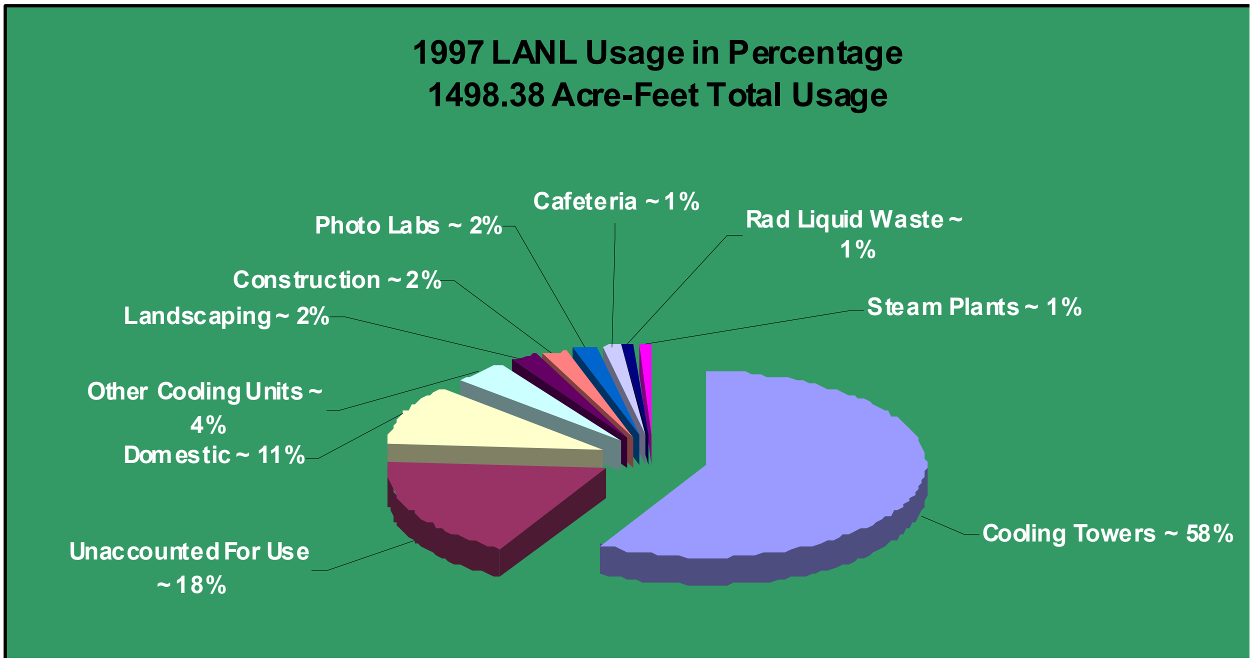


Figure 10. LANL Environmental Roadmap: Water Usage at LANL in 1997

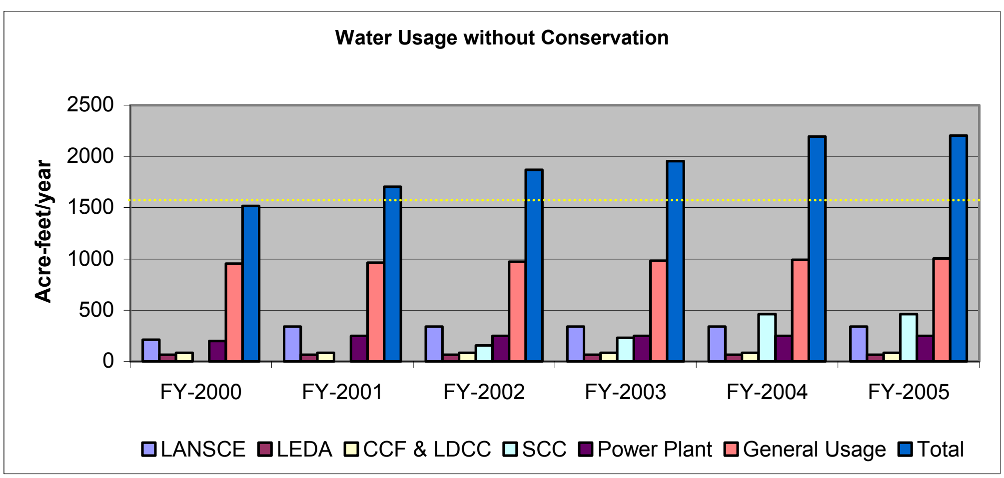


Figure 11. LANL Water Usage between FY00 and FY05 without Conservation

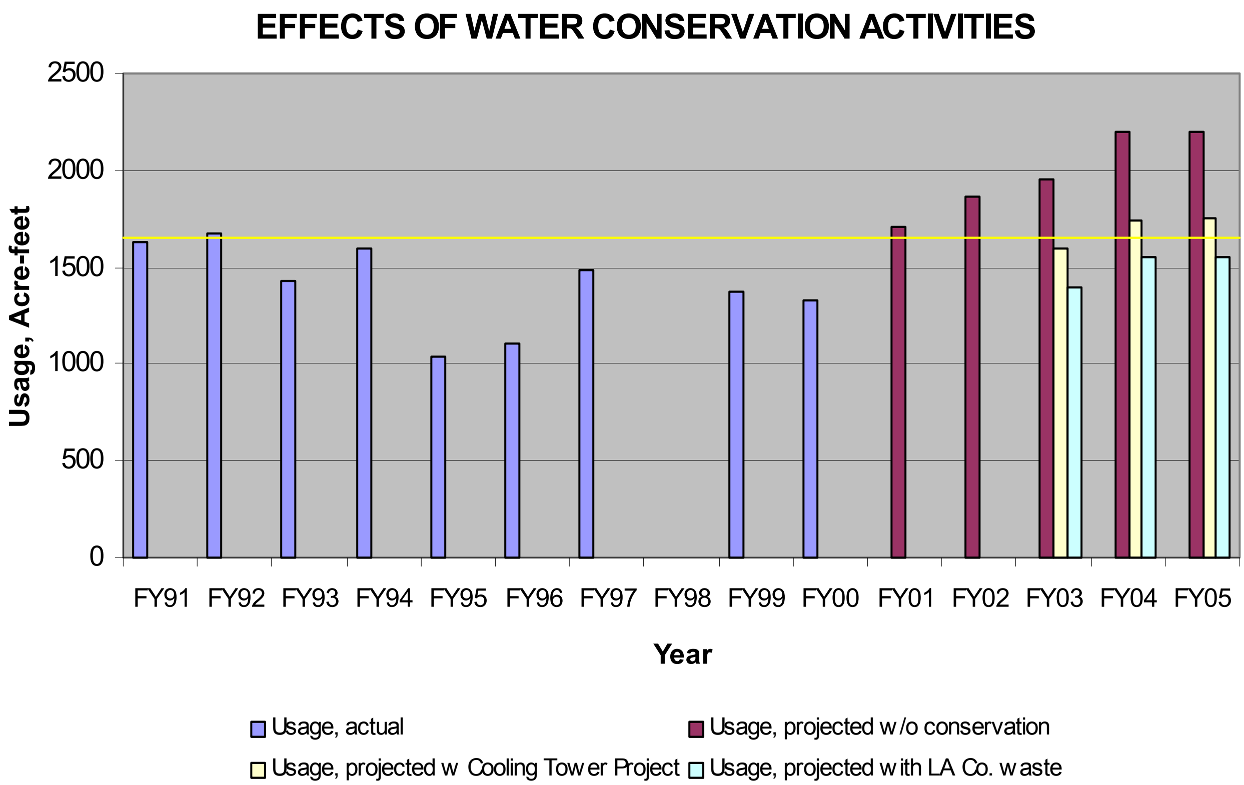


Figure 12. Effects of Water Conservation Activities, FY00–FY05

1) actual use from FY ’91 – FY ’00; 2) projected use from FY ’01–FY ’05 without any conservation; 3) projected use from FY ’01–FY ’05 if Bretske, et al., ’01 Project is implemented (project would increase the number of cooling tower cycles by removing silica from water); 4) projected use from FY ’01–FY ’05 if Bretske and Kerven project are both implemented (Hanson, 2001).

Theoretically 200,000 GPD or ~223 AFY less water will be pumped from the regional aquifer. This translates to a decline in the rate of regional aquifer draw down, estimated by both the Jemez y Sangre Water Planning Council (2001) and LANL Site Wide Environmental Impact Statement (1999) to be 1-2 feet per year compared with a 500- to 1,500-foot-thick saturation zone of the aquifer. However, if the current understanding of the regional aquifer is not accurate, annual draw down could be more significant. In either case the conservation of ~223 AFY is very valuable. A population increase of 15 percent or 3,000 persons by the year 2060, as projected by the Bureau of Business and Economic Research (Alcantara, 2000), increases water demand by approximately 660 AFY. Los Alamos County has a recognized water right of 5,541.3 AFY (Jemez y Sangre, 2001).

Environmental Costs

A one-page NEPA review was done by the Ecology Group (LANL, 2000). A formal Environmental Impact Study will be done by Environment Safety & Health (ESH-20) as soon as project is funded. No environmental obstacles to the implementation of this project are anticipated at this point. Following is an excerpt from the NEPA review:

> After specific locations are identified, LANL cultural and biological resources staff would survey the areas to ensure that no cultural resources or sensitive biological resources exist in the area. All water quality requirements, including submittal of a Notice of Change Condition of NPDES Permits, would be complied with as identified by LANL's water quality staff. Best management practices would be followed to minimize erosion during construction activities.
>
> The proposed project may result in increased effluent release. Excess effluent would be diverted to TA-53, to be used in existing cooling towers discharging to NPDES outfalls. Effluent flow to these NPDES outfalls may significantly change effluent volume. This flow, and how it may affect wetlands, is currently being evaluated by the LANL biologists".

Financial Analysis

As measured by changes in cash flows, the project would have the following impact:

- Reduced purchases of water from Los Alamos County save LANL roundly \$158,000 per year (200,000 GPD x \$2.17 per thousand gallons x 365 days) (Glasco, 4/12/00).

- Reduced expenditures of approximately \$200,000 for special waste disposal. A more robust population of microorganisms allows a relaxed Waste Acceptance Criteria to accept both Mixed Low Level Waste (MLLW) generated by the bioassay labs to be sent to SWS (i.e., photochemical, ferric chloride etchant, acids and bases after neutralization) and Area L Sump Rainwater, cleaning chemicals, etc. currently in the hazardous waste stream (Carlson, 2001).

<u>Waste management costs per item</u>

Collection/Packaging/Shipping and Transportation Costs
~ 70 Hazardous items
~ 80 MLLW items
Packaging 2 hrs labor + \$20.00 container = \$120.00
Characterization = \$500.00
Complete Chemical Waste Disposal Request and Waste Profile Form –
1 hour @ \$50.00
Transportation to TA-54 = \$10.00
Cost per item = \$680.00 * 150 items = \$102,000

<u>Treatment/Storage/Disposal costs</u>

Hazardous Waste 10,000 kg * 5.92/kg =	\$59,200
Mixed Low Level Waste 1047 kg/yr * \$36.84/kg =	<u>\$38,571</u>
Total	\$199,771 or ~\$200K

- Elimination of the need for purchases of dog food supplements to the aeration basins over the Christmas holidays [250 lbs per day at a cost of \$75 per day, roundly \$750 for the ten-day holiday period (Ayers, 5/6/01)].

- Capital expenditures of \$950,000 for construction of lift station, tie-in and assorted project management studies, including EIS. Table 4 shows an itemized cost breakdown of infrastructure, design-build, oversight, contingency, etc. costs from a feasibility study completed in May 2001 by Jacobs Engineering, Inc.

- Estimated yearly expenditure of \$30K for treating additional influent and disposing of additional sludge.

Assuming no interest charges, repayment would occur in approximately 2.8 years with the savings of \$358,000 continuing for the life of the project, another 17.2 years.

Economic Analysis

A more complete economic analysis would also include:

- Interest cost on the $950,000 in capital investment either by amortizing, as in a home mortgage, the capital investment as a debt or discounting the future stream of $358,000 annual savings to a present value comparable to the capital cost. For example, Table 5 uses a discount rate of 10 percent, an assumed real discount rate of 7 percent plus an assumed inflation rate of 3 percent, to illustrate that the breakeven point would not occur until the fifth year. These assumed rates are higher than the 2000 OMB nominal rate. The impact of using the lower discounting factor of 6.2 percent (4.1 real + 2.1 inflation) would be to increase the dollar amount of the savings each year, thus increasing the total savings and reducing the period before "break-even."

- LANL could be fined up to $100,000 a day if SWS is found to be out of compliance with environmental regulations. (Barnett, 7/14/00)

- The risk that LANL could be shut down from a few days to eight weeks if a significant kill-off of microorganisms occurred, as there would be no functional toilets or running water. Table 6 estimates the cost of a LANL shutdown (Herring, 2001).

Table 4. Itemized Project Cost from Feasibility Report by Jacobs Engineering

ITEMS	**$K**
Design/build (including 6% tax)	$520
LANL Engineering Project Management Oversight	10
LANL Engineering CM Oversight	4
Procurement Costs	5
Johnson Control Northern New Mexico Costs (JCNNM)	4
LANL Environmental Study/Assessment	72
LANL Construction PM Oversight	25
LANL Construction CM Oversight	50
Other Project Costs	41
G & A	15
Subtotal	*$745*
Escalation	15
Contingency	190
Total	**$950**

NOTE: Jacobs Engineering, Inc. used a daily influent diversion of 0.23 MGD

Table 5. Discounted and Non-Discounted Cumulative Savings and Breakeven Year

Initial Investment	**950**
Inflation Rate	**0.03%**
Discount Rate	**0.10%**
Savings	**358**
Operating Cost	**30**

Dollar Amounts in Thousands

					Cumulative Discounted	
Year	**Capital**	**Savings**	**Operating**	**Net Savings**	**Savings**	**Non-Discounted**
1	950	0	0	-950	-950	-950
2	0	358	30	288	-662	-622
3	0	358	30	269	-393	-294
4	0	358	30	252	-141	(Breakeven) 34
5	0	358	30	236	95	362
6	0	358	30	221	316	690
7	0	358	30	207	523	1,018
8	0	358	30	194	717	1,346
9	0	358	30	181	899	1,674
10	0	358	30	170	1,068	2,002
11	0	358	30	159	1,228	2,330
12	0	358	30	149	1,377	2,658
13	0	358	30	140	1,516	2,986
14	0	358	30	131	1,647	3,314
15	0	358	30	122	1,769	3,642
16	0	358	30	115	1,884	3,970
17	0	358	30	107	1,991	4,298
18	0	358	30	100	2,091	4,626
19	0	358	30	94	2,185	4,954
20	0	358	30	88	2,273	5,282
21	0	358	30	82	2,356	5,610

The discounted total was calculated by estimating today's savings and costs, applying an inflation factor of 0.03 percent each year to the projected savings, and then discounting the savings by .10%. Year 2 is really the first year of savings and the equation is $328K * $(1.03/1.1)^2$. Year 3 this formula is cubed, and so forth.

Table 6. Cost of LANL Shutdown for One Day

LANL	$3,391,921 (salary plus fringe)
Contract Labor	388,798
JCNNM	335,637
Total	$4,116,356

NOTE: The calculation is determined by using the Work Force Report prepared for the month of March taking the March Salary plus Benefits total divided by the productive hours (which calculates the cost for one hour), times 9 hours per day.

This cost does not include the lost G&A.

The summer cost-per-day is a little bit more expensive since we also have the student labor cost

Intangible Benefits

These benefits definitely have a financial component, but do not easily lend themselves to being quantified.

- In FY00, LANL used ~1500 AF; each year that 200,000 GPD of effluent are reused, LANL will save ~ 223 acre feet, or ~15 percent of the current water budget. This generates a reserve of water for future projects to carry out LANL's mission.
- A legal agreement of some kind will be executed between LAC and LANL. This will allow LANL to plan accordingly.
- This project will demonstrate to the wider community that LANL is committed to water conservation, environmental responsibility and concern for public welfare.

Such good will is priceless to an institution with a reputation for not caring about the impact of its research on the surrounding environment.

Intangible Costs

LANL will be committed for a certain length of time to a binding legal agreement with Los Alamos County. A hypothetical example: LANL could decide to cool industrial processes using electricity-powered chillers, which would significantly reduce the amount of reuse water needed for cooling towers.

The risk of terrorist sabotage coming through County wastewater collection system into SWS cannot be quantified. The risk of a toxic household waste dump that would significantly contaminate LANL SWS is unlikely, but possible.

Summary

Table 7 itemizes all cost and benefits for LANL and Table 8 compares discounted and non-discounted totals for quantifiable costs and benefits.

Table 7 Itemized Benefits-Costs to LANL of Project Implementation

	Benefits	**Costs**
Operation	1. Improved daily operation	1. Liability for terrorist sabotage through County
	2. Reduced risk of plant upsets or violations	2. Liability for toxic household dump from LAC
	3. Reduced risk of total microorganism kill	
	4. Improved water quality	
Environmental	1. Approximately 223 AFY of reuse water replaces potable water in cooling towers	
	2. Approximately 223 AFY less groundwater pumped	
	3. Minimum decline in aquifer draw down of 1-2 feet/year.	
Economic	1. $158K/yr saved by not purchasing 200K GPD of water from LAC for cooling towers	1. $950K on infrastructure
	2. $200K/yr saved on cost of disposing of hazardous and mixed low level waste streams	
	3. Risk reduction of incurring fine if SWS is out of compliance ($25K-$100K/per day)	3. $30K to treat additional wastewater and dispose of additional sludge.
	5. Risk reduction of partial or complete LANL shutdown because of total microorganism kill ($4M/day)	
	6. Dog food over Christmas (~$750)	
Intangible	1. Margin of water rights saved for future projects	1. Resulting constraint from binding legal contract with LAC; LANL would be forced to continue taking water.
	2. LANL can plan for the next 20 years	
	3. Demonstration of environmental responsibility	
	4. Creation of favorable public relations in community	

Table 8. Comparison of Quantifiable Benefits and Costs to LANL

Non-Discounted		Discounted	
Benefits	**Costs**	**Benefits**	**Costs**
200K GPD ($158K x 20) = **$3,160K**	Lift station & Tie-in (year one) = **$950K**	Discounted yearly savings of **$328K** ($358K-$30K)	**$950K** capital investment compounded yearly at 3% interest over 20 years
Waste Disposal ($200K x 20 years) = **$4,000K**	Maintenance ($30K x 20 years) = **$600K**		
Total Benefits = $7.2 M	**Total Costs = $1.6 M**	**Total Benefits = $2.3M**	**Total Costs = $1.7M**

Discounted and non-discounted dollars result in a significant dollar difference, however both save money.

Los Alamos County Benefits

Environmental

Los Alamos County benefits by diverting some influent away from old Bayo Canyon plant which is operating at full capacity. By reducing influent load, the County continues to generate good quality effluent which will return to the environment in one form or another. LAC will also gain some time for the construction of a new county wastewater treatment plant.

Economic

A reduction in water sold to LANL generates more available water in the future for County growth.

Intangible

LAC benefits by being seen as a good steward of resources in assisting LANL to conserve potable water (which might politically effect LAC's chances of retaining and developing its San Juan Chama right).

Los Alamos County Costs

Environmental

No environmental costs have been identified.

Economic

LAC loses approximately $236.00 per day when income loss from water sales to LANL is balanced with savings from treatment cost of 200,000 GPD @ $0.99 per thousand gallons (T. Glasco, LAC Water Resources Director, 3/12/00, personal communication). The total net loss over 20 years is approximately $1.7M.

Income from water sold to LANL	Expense of treating water sold to LANL
$434.00 per day	$198.00 per day

LAC will have 200,000 GPD less of reuse water; most of this has been used to water the golf course.

The opportunity cost of contractual obligation to deliver this water to LANL regardless of unanticipated opportunities to use or lease water rights that might occur during the next 20 years.

Intangible

No intangible costs have been identified.

7.0 CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The two most important objectives are met by the solution to divert influent from Los Alamos County into the LANL Sanitary Wastewater System. Plant operation will be stabilized and more than 200AFY of water will be conserved. Additionally, 1) potable water currently used in cooling towers will be replaced with reuse water, 2) the life of the regional aquifer is extended by a reduction in annual draw down, 3) a reserve of water for future LANL projects is generated, and 4) good stewardship of natural resources reflects well on LANL's role in the community of Northern New Mexico.

The benefit-cost analysis reveals a significant benefit-to-cost ratio on non-discounted dollars, resulting in a net gain of $5.6M for LANL. The discounted benefit-to-cost ratio results in a net gain of $.6M to LANL.

Recommendations

The Benefit-Cost Analysis demonstrates that benefits far exceed costs so the recommendation is for this project to be funded as soon as possible. Economically the quantifiable benefit is far more favorable when project dollars are not discounted, although some money is saved either way. Since cutting costs is not the reason this project is being done, even minor savings can be seen as a 'perk." Moreover, some of the benefits of this project that could not be quantified certainly do have economic value.

At least three separate flow diversion regimes could be employed to meet the objective of an increased, more consistent organic load. One possibility is to raise the weekend and holiday organic load so that it equals the mid-week organic load (i.e. influent is added *only* on weekends and holidays). A second possibility is to add influent seven days per week, with a lower increment mid-week and a higher increment weekends and holidays. The first possibility would mean fewer adjustments in the established SWS operation; smaller flow volumes also allow for more detention time and a higher quality effluent. In order to accommodate more flow (option two), detention time would have to be shortened and this might require the unused aeration basin and clarifier to be put on-line. A third possibility is to take influent from LAC during winter on a daily basis, diverting more on weekends than weekdays, but the rest of the year diverting influent *only* on weekends and holidays. Los Alamos County would prefer the later since it uses its effluent in the summer for irrigating municipal lawns.

The final recommendation is that 200,000 GPD of Los Alamos County influent be added to the sanitary wastewater treatment facility at Los Alamos National Laboratory. Scenarios that add such a substantial amount of County influent to SWS will result in the availability of more reuse water for cooling towers and more water conserved for future LANL projects. This volume of additional influent will maximize dilution of toxics and reduction in plant vulnerability. Two hundred thousand gallons per day will raise SWS from the low end of the design scale to the middle to upper end of the .6 million gallon per day wastewater treatment facility.

8.0 GLOSSARY

ACTIVATED SLUDGE—The *Floc* produced in raw or settled wastewater due to the growth of bacteria and other organisms in the presence of *Dissolved Oxyge*n. It is the product that results when primary effluent is mixed with bacteria-laden sludge and then agitated and aerated to promote biological treatment, speeding the breakdown of organic matter in raw sewage undergoing secondary waste treatment.

ACTIVATED SLUDGE PROCESS—A method of *Secondary Wastewater Treatment* in which the waste is treated by microorganisms in a well-aerated tank to degrade the organic material. A sedimentation tank is then used to remove the resultant sludge.

ADSORB.—To attract and retain gas or liquid molecules on the surface of another material. See Absorb.

AERATION—The process of adding air to water. Air can be added to water by either passing air through water or passing water through air.

AEROBIC—A condition in which "free"atmospheric or dissolved oxygen is present in the water.

AGGLOMERATION—The collecting or coalescence of dispersed suspended matter into larger masses or flocs which can settle and be filtered from water.

ALKALINITY—The capacity of water to neutralize acids. This capacity is caused by the water's content of carbonate, bicarbonate, hydroxide and occasion- ally borate, silicate, and phosphate. Alkalinity is not the same as pH because water does not have to be strongly basic (high pH) to have a high alkalinity. Alkalinity is a measure of how much acid can be added to a liquid without causing a great change in pH.

AMOEBA—A protozoan of the genus *Amoeba* or related genera, occurring in water and soil and as a parasite in other animals. An amoeba has no definite form and consists essentially of a mass of protoplasm containing one nucleus or more surrounded by a delicate, flexible outer membrane. It moves by means of pseudopods.

ANOXIC—Denotes the absence of oxygen, as in a body of water.

ANAEROBIC—A condition in which "free" (atmospheric) or dissolved oxygen is NOT present in water.

AQUIFER—A natural underground layer of porous, water-bearing materials (sand, gravel) usually capable of yielding a large amount or supply of water.

BACTERIA—Bacteria are living organisms, microscopic in size, which usually consist of a single cell. Most bacteria use organic matter for their food and produce waste products as a result of their life processes. In the case of activated sludge, the bacterial culture refers to the group of bacteria classified as AEROBES, and FACULTATIVE organisms, which covers a wide range of organisms. Most treatment processes in the United States grow facultative organisms which use the carbonaceous (carbon compounds) BOD**.** Facultative organisms can live when oxygen resources are low. When "nitrification" is required, the nitrifying organisms are OBLIGATE AEROBES (require oxygen) and must have at least 0.5 mg/L of dissolved oxygen throughout the whole system to function properly.

BENEFIT-COST ANALYSIS - A systematic quantitative method of assessing the desirability of Government projects or policies when it is important to take a long view of future effects and a broad view of possible side-effects.

BIOCHEMICAL OXYGEN DEMAND (BOD)—The amount of oxygen consumed by microorganisms (mainly bacteria) and by chemical reactions in the biodegradation of organic matter.

BRINE—Water with a high salt content.

COMPLIANCE MONITORING—(Water Quality) Collection and evaluation of data, including self-monitoring reports, and verification to show whether pollutant concentrations and loads contained in permitted discharges are in compliance with the limits and conditions specified in the permit.

COMPLY (EPA)—A term used to indicate compliance or adherence with *Clean Water Standard*s, specifically with respect to a schedule or plan ordered or approved by a court of competent jurisdiction, the *U.S. Environmental Protection Agency (EPA*), or a water pollution control agency in accordance with the requirements of the *Federal Water Pollution Control Act (Clean Water Act) [Public Law 92–500]* and regulations issued pursuant thereto.

COOLING TOWER—A large tower or stack that is used for heat exchange of once-through cooling water generated by steam condensers. Hot water from the plant is sprayed in the tower and exchanges heat with the passing air. The water is then collected at the bottom of the tower and used again. A small amount of water is lost (consumed) through evaporation in this process.

COOLING WATER—Water used for cooling purposes by electric generators, steam condensers, large machinery or products at industrial plants, and nuclear reactors. Water used for cooling purposes can be either fresh or saline and may be used only once or recirculated multiple times.

CLARIFICATION—A process or combination of processes where the primary purpose is to reduce the concentration of suspended matter in a liquid

COLLOIDS—(1) Any substance with particles in such a fine state of subdivision dispersed in a medium (for example, water) that they do not settle out, but not in so fine a state of subdivision that they can be said to be truly dissolved. (2) Quantities of extremely small particles, typically 0.0001 to 1 micron in size, and small enough to remain suspended in a fluid medium without settling to the bottom. Substances that, when apparently dissolved in water or other liquid, diffuse not at all or very slowly through a membrane and show other special properties, as lack of pronounced effect on the freezing point or vapor pressure of the solvent. Colloids represent intermediate substances between a true dissolved particle and a suspended solid, which will settle out of solution.

CHLORINE-CONTACT CHAMBER—(Water Quality) In a wastewater treatment plant, a chamber in which effluent is disinfected by chlorine before it is discharged to the receiving waters.

DECANT—To draw off the upper layer of liquid after the heaviest material (a solid or other liquid) has settled.

DENITRIFICATION—The removal of nitrate ions (NO_3^-) from soil or water; involves the *Anaerobic* biological reduction of nitrate to nitrogen gas. The process reduces desirable fertility of an agricultural field or the extent of undesirable aquatic weed production in aquatic environments.

DENITRIFYING BACTERIA—Bacteria in soil or water that are capable of anaerobic respiration, using the nitrate ion as a substitute for molecular oxygen during their metabolism. The nitrate is reduced to nitrogen gas (N2), which is lost to the atmosphere during the process.

DISCOUNT RATE - The interest rate used in calculating the present value of expected yearly benefits and costs.

DISSOLVED OXYGEN (DO)—(1) Concentration of oxygen dissolved in water and readily available to fish and other aquatic organisms. (2) The amount of free (not chemically combined) oxygen dissolved in water, wastewater, or other liquid, usually expressed in milligrams per liter, parts per million, or percent of saturation. Dissolved oxygen levels are considered the most important and commonly employed measurement of water quality and indicator of a water body's ability to support desirable aquatic life. The ideal dissolved oxygen level for fish is between 7 and 9 milligrams per liter (mg/L); most fish cannot survive at levels below 3 mg/L of dissolved oxygen. Secondary and advanced wastewater treatment techniques are generally designed to ensure adequate dissolved oxygen in waste-receiving waters.

DRAWDOWN—a lowering of the ground-water surface caused by pumping.

EFFLUENT—water that flows from a sewage treatment plant after it has been treated electrolysis

FILAMENTOUS ORGANISM—Organisms that grow in a thread or filamentous. Common types are Thiothrix and Actinomycetes. A common cause of sludge bulking in the activated sludge process.

FLOC—Clumps of bacteria and particles or coagulants and impurities that have come together and formed a cluster. Found in aeration tanks, secondary clarifiers and chemical precipitation processes.

FLOCCULATION—The gathering together of fine particles after coagulation to form larger particles by a process of gentle mixing.

FROTHING—A mass of bubbles in or on a liquid; foam

FUNGI (Singular: Fungus)—Molds, mildews, yeasts, mushrooms, and puffballs, a group of organisms lacking in chlorophyll (i.e., are not photosynthetic) and which are usually non-mobile, filamentous, and multicellular. Some grow in soil, others attach themselves to decaying trees and other plants whence they obtain nutrients. Some are *Pathogen*s, others stabilize sewage and digest composted waste.

LOAD—the quantity of a substance entering receiving waters.

MIXED LIQUOR—When the activated sludge in an aeration tank is mixed with primary effluent or the raw wastewater and return sludge, this mixture is then referred to as mixed liquor as long as it is in the aeration tank. Mixed liquor also may refer to the contents of mixed aerobic or anaerobic digesters.

MIXED LIQUOR SUSPENDED SOLIDS (MLSS)—Suspended solids in the mixed liquor of an aeration tank.

MIXED LIQUOR VOLATILE SUSPENDED SOLIDS (MLVSS)—The organic or volatile suspended solids in the mixed liquor of an aeration tank. This volatile portion is used as a measure or indication of the microorganisms present.

MOTILE—Capable of selfpropelled movement. A term that is sometimes used to distinguish between certain types of organisms found in water.

NOCARDIA—A type of filamentous bacteria

NUTRIENT—Any substance that is assimilated (taken in) by organisms and promotes growth. Nitrogen and phosphorus are nutrients which promote the growth of algae. There are other essential and trace elements which are also considered nutrients

NITRIFICATION—An aerobic process in which bacteria reduce the ammonia and organic nitrogen in water into nitrite and then nitrate.

OUTFALL—Point of discharge into the receiving waters.

PATHOGENIC ORGANISMS—Organisms, including bacteria, viruses or cysts, capable of causing diseases (giardiasis, cryptosporidiosis, typhoid, cholera, dysentery) in a host (such as a person). There are many types of organisms which do *NOT* cause disease. These organisms are called nonpathogenic.

PH—numeric value that describes the intensity of the acid or basic (alkaline) conditions of a solution. The pH scale is from 0 to 14, with the neutral point at 7.0. Values lower than 7 indicate the presence of acids and greater than 7.0 the presence of alkalis (bases). Technically speaking, pH is the logarithm of the reciprocal (negative log) of the hydrogen ion concentration (hydrogen ion activity) in moles per liter.

POTABLE WATER—Water that does not contain objectionable pollution, contamination, minerals, or infective agents and is considered satisfactory for drinking.

PRIMARY TREATMENT—A wastewater treatment process that takes place in a rectangular or circular tank and allows those substances in wastewater that readily settle or float to be separated from the wastewater being treated. A septic tank is considered primary treatment.

PROTOZOA—A group of motile microscopic organisms (usually single celled and aerobic) that sometimes cluster into colonies and often consume bacteria as an energy source.

RAS—Return Activated Sludge, mg/L. Settled activated sludge that is collected in the secondary clarifier and returned to the aeration basin to mix with incoming raw or primary settled wastewater.

RISING SLUDGE—Rising sludge occurs in the secondary clarifiers of activated sludge plants when the sludge settles to the bottom of the clarifier, is compacted, and then starts to rise to the surface, usually as a result of denitrification

ROTIFERS—Microscopic animals characterized by short hairs on their front end present in larger numbers as sludge ages.

SECONDARY CLARIFIER—A wastewater treatment device which consists of a rectangular or circular tank that allows those substances not removed by previous treatment processes that settle or float to be separated from the wastewater being treated.

SEDIMENTATION—The process of settling and depositing of suspended matter carried by wastewater. Sedimentation usually occurs by gravity when the velocity of the wastewater is reduced below the point at which it can transport the suspended material

SEED—In wastewater treatment, seed, seed culture or seed sludge refers to a mass of sludge that contains populations of microorganisms. When a seed sludge is mixed with wastewater or sludge being treated, the process of biological decomposition takes place more rapidly.

SEPTIC—A condition produced by anaerobic bacteria. If severe, the wastewater produces hydrogen sulfide, turns black, gives off foul odors, contains little or no dissolved oxygen, and the wastewater has a high oxygen demand.

SUPERNATANT—Liquid removed from settled sludge. Supernatant commonly refers to the liquid between the sludge on the bottom and the scum on the surface of a basin. This liquid is usually returned to the influent wet well or to the primary clarifier.

THICKENING—Treatment to remove water from the sludge mass to reduce the volume that must be handled.

TOTAL SUSPENDED SOLIDS (TSS)—The measurement of the amount of solid matter in the wastewater or effluent, usually moved in parts per million.

TOXICITY—The relative degree of being poisonous or toxic. A condition which may exist in wastes and will inhibit or destroy the growth or function of certain organisms.

VOLATILE SOLIDS—Those solids in water or other liquids that are lost on ignition of the dry solids at 550°C.

WAS—The excess growth of microorganisms which must be removed from the process to keep the biological system in balance.

WASTEWATER COLLECTION SYSTEM—The pipe system for collecting and carrying water and water-carried wastes from domestic and industrial sources to a wastewater treatment plant.

WEIR—1) A wall or plate placed in an open channel and used to measure the flow of water. The depth of the flow over the weir can be used to calculate the flow rate, or a chart or conversion table may be used to convert depth to flow, 2) A wall or obstruction used to control flow (from settling tanks and clarifiers) to ensure a uniform flow rate and avoid shortcircuiting. (Office of Water Programs)

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APPENDIX A

Physical and Chemical Characteristics of Wastewater

PHYSICAL AND CHEMICAL CHARACTERISTICS OF WASTEWATER

The following are some of the physical and chemical characteristics of wastewater and how they interact and are affected by Biochemical Oxygen Demand (BOD), the primary indicator of the organic material.

Biochemical Oxygen Demand

BOD is the rate at which organisms use the oxygen in wastewater to metabolize and stabilize organic matter under aerobic conditions; it is inversely proportional to the dissolved oxygen in the water. When effluent is discharged to a water body, an NPDES permit requires it to meet an effluent standard that will protect the receiving waters and fish from anoxic conditions. (Global, 1997) Over the history of the NPDES permit program, the EPA has addressed water quality as impacted primarily by oxygen demanding parameters. This has occurred through the use of specific-State water quality standards for specific pollutants. (NPDES, 1999) SWS must release effluent BOD < 30 mg/L. SWS releases effluent BOD <2mg/L most of the time (Appendix E).

BOD is measured two ways, mg/L and pounds. Knowing the mg/L of BOD as well as the flow (MGD) allows the operator to calculate the pounds of BOD. BOD mg/L is measured weekly in a lab test called, BOD-5. This measures the rate of oxygen use under controlled conditions of time and temperature. There is a five-day lag before results are known, thus the name BOD-5. This test is performed three times per month by JCNNM for SWS and the results are used to check calculations from previous week.

The formula for calculating pounds of BOD is:

BOD (lbs) = (Flow, MGD) X (BOD, mg/L) X (8.34/lbs/gal) (Kerri, K., 1998)

Where, MGD = millions of gallons per day
8.34 = weight in pounds of a gallon of water

If SWS has a flow of 0.35MGD (maximum flow for SWS) from Monday to Friday, and the BOD is 150 mg/L, then:

$$\text{BOD (pounds)} = \frac{0.35\text{MGD X } 150 \text{ mg/L X } 8.34}{1 \text{ MGD}} = \sim 438 \text{ pounds of BOD}$$

On Saturday, Sunday, and Monday, the pounds of BOD per day might be:

$$\frac{0.15\text{MGD X } 100 \text{ mg/L X } 8.34}{1 \text{ MGD}} = \sim 125 \text{ pounds of BOD}$$

If, LAC diverts 0.2MGD into SWS, and the BOD is 250 mg/L, then:

$$\frac{0.2\text{MGD X } 8.34 \text{ X } 250 \text{ mg/L}}{1 \text{ MGD}} = \sim 417 \text{ pounds of BOD per day would be added to SWS}$$

If LAC diverts 0.2MGD with 400 mg/L BOD, then the additional pounds of BOD is ~ 667. The BOD mg/L cannot be controlled; however, the additional flow from LAC can be controlled, so that the pounds of BOD stays relatively consistent for the microorganisms. This will require a lot of trial and error at the beginning since many combinations are possible.

Four sets of data were collected from Los Alamos County on BOD; some data sets have sample results for pH, TSS, TDS, COD, and microtoxicity. The samples were collected on 6 days between August 31, 2000 and April 4, 2001. The data sets are in Appendix E with notes from lab analyst. The BOD results cover a range from 35 mg/L – 450 mg/L, excluding one outlier, and do not indicate any obstacle to continuing with this project. The microtoxicity results are in many cases higher than the SWS Waste Acceptance Criteria (WAC), but additional organic load (BOD + flow MGD), will provide more robust microorganisms to handle higher

WAC limits. Finally, the plant will be operating in middle range of its designed capacity and this will also contribute to raising the WAC limit.

Total Suspended Solids (TSS)

The importance of total suspended solids has to do with the turbidity of the discharged water. Too many suspended solids will block the sunlight to photosynthetic plants and this will alter the aquatic community that depends on green plants as an important component of the food chain. The maximum concentration of effluent TSS as determined by NPDES must be <30 mg/L. The average influent TSS at SWS is 240 mg/L and the average effluent TSS is 3.0 mg/L. Figure 13 shows TSS influent and effluent range for the year 2000. Note that influent is read from the left and effluent is read from the right.

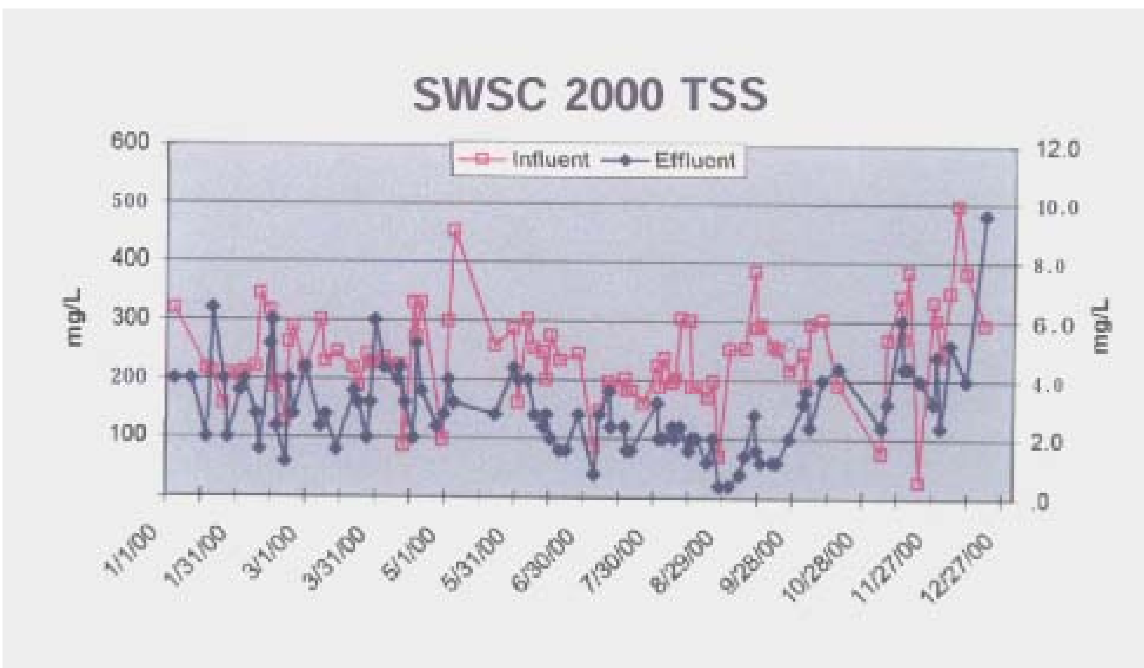

Figure 13. Influent and Effluent Total Suspended Solids at SWS during 2000.

Mixed Liquor Suspended Solids (MLSS)

MLSS is the concentration of suspended solids in activated sludge mixed liquor, expressed in mg/L. ‘Solids’ (MLSS) really means the microorganisms, although there is grease, hair, and some uneaten solids of all varieties.

SWS uses “Mean Cell Residence Time” (MCRT) to determine the proper amount of MLSS in the aeration basin, which determines how much to waste. Average mg/L of MLSS is 2,000-3,500. MCRT is the average time that a microorganism will spend in the activated sludge process. Water temperature is used to select proper MCRT (Water temperature and MCRT are inversely proportional). The equation is:

$$\text{MCRT days} = \frac{\text{MLSS (lbs)}}{\text{WAS (lbs of SS)} + \text{Effluent (lbs of SS)}}$$

$$\text{MCRT of 45 days} = \frac{\text{MLSS (lbs) [.750 MGD x 2500 mg/L x 8.34 lbs/gal}}{\text{WAS (lbs) [? MGD X 5000 mg/L X 8.34 lbs/gal] + EFF (lbs) [.250 MGD x 4 mg/L x 8.34 lbs/day}}$$

$$\text{? MGD X 5000 mg/L X 8.34 lbs/gal} = \frac{\text{.750 MGD x 2500 mg/L x 8.34 lbs/gal]}}{\text{45 days}} - \text{.250 MGD x 4 mg/L x 8.34 lb/d}$$

$$\text{? MGD} = \frac{339}{\text{5000 mg/L X 8.34 lbs/gal}}$$

.008 MGD = WAS flow

then, solve for pounds of WAS, which can be converted from flow (MGD), using 2 x MLSS for the return activated sludge suspended solids (RASSS) in the following equation:

$$\text{Flow (MGD)} = \frac{\text{WAS (lbs)}}{\text{RASSS x 8.34}}$$

$$\text{.008 MGD} = \frac{\text{WAS (pounds)}}{\text{5000 mg/L x 8.34}} = \text{\textasciitilde 334 pound of WAS}$$

Mixed Liquor Volatile Suspended Solids (MLVSS)

MLVSS provides a general indication of the concentration of *active* microorganisms in the mixed liquor. SWS keeps track of MLVSS in order to measure the percent of volatile solids to total suspended solids (~ 75 percent).

The Effects of pH

The enzymes that regulate many of the biochemical reactions in bacteria are very pH dependent. The optimum pH in the aeration basin should be between 7.0 and 7.5 for the proper activated sludge microorganisms to dominate. Figure 14 shows November 2000 influent pH.

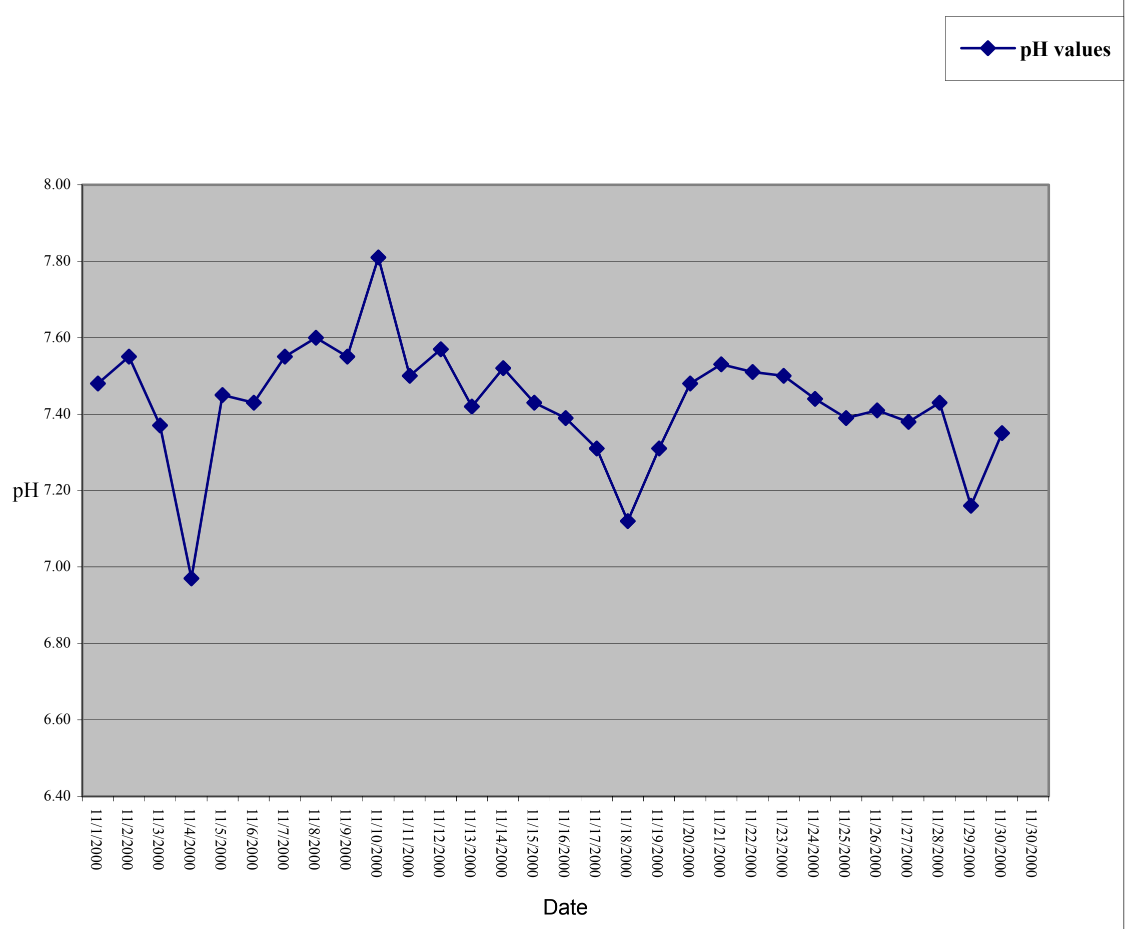

Figure 14. November 2000 SWS pH Values

Nitrification–Denitrification

Effluent released to water bodies must contain the least possible concentration of nitrates, and this is accomplished by nitrification and denitrification. One of the SWS effluent parameters mandated by the State of New Mexico Ground Water Bureau is total nitrogen, which must measure < 10 mg/L (Figure 15).

Alternating periods of dissolved oxygen in the aeration basin then no free oxygen in the aeration basin allows the nitrification/denitrification process to occur. The end product of this process is nitrogen gas released to the atmosphere.

Ammonia (NH_4), essential to the growth of nitrobacters, enters the plant as urea**.** With dissolved oxygen (DO) from aeration, the nitrifying bacteria will convert NH_4 ---> NO_2--->NO_3. This is nitrification (Figure 16). If there is a food source (i.e., carbon), then bacterial enzymes break up the NO_3, allowing the O_2 to be used by the bacteria, and releasing the N_2 as nitrogen gas, which bubbles up and volatilizes into the atmosphere. This is called denitrification. This will only happen when all the ‘free’ dissolved oxygen is used up, and the bacteria are forced to break down the 'bonded' oxygen in the NO_3molecule for their survival. The necessary conditions are an anoxic zone and carbon to provide energy for bacteria to produce the enzymes, a delicate balance. If all BOD is consumed in the aeration basin while nitrification is occurring there is not enough carbon left for the denitrification process.

Through trial and error, it was determined by SWS operators that DO must be between 0.5 mg/L and 1.0 mg/L for the microorganisms to metabolize the BOD and for the nitrobacter microorganisms to aid in the nitrification of the ammonia (NH_4). This upper limit of 1.0 mg/L is less than the standard for wastewater treatment plants and illustrates that the established standards do not always work and operators frequently must customize plant processes.

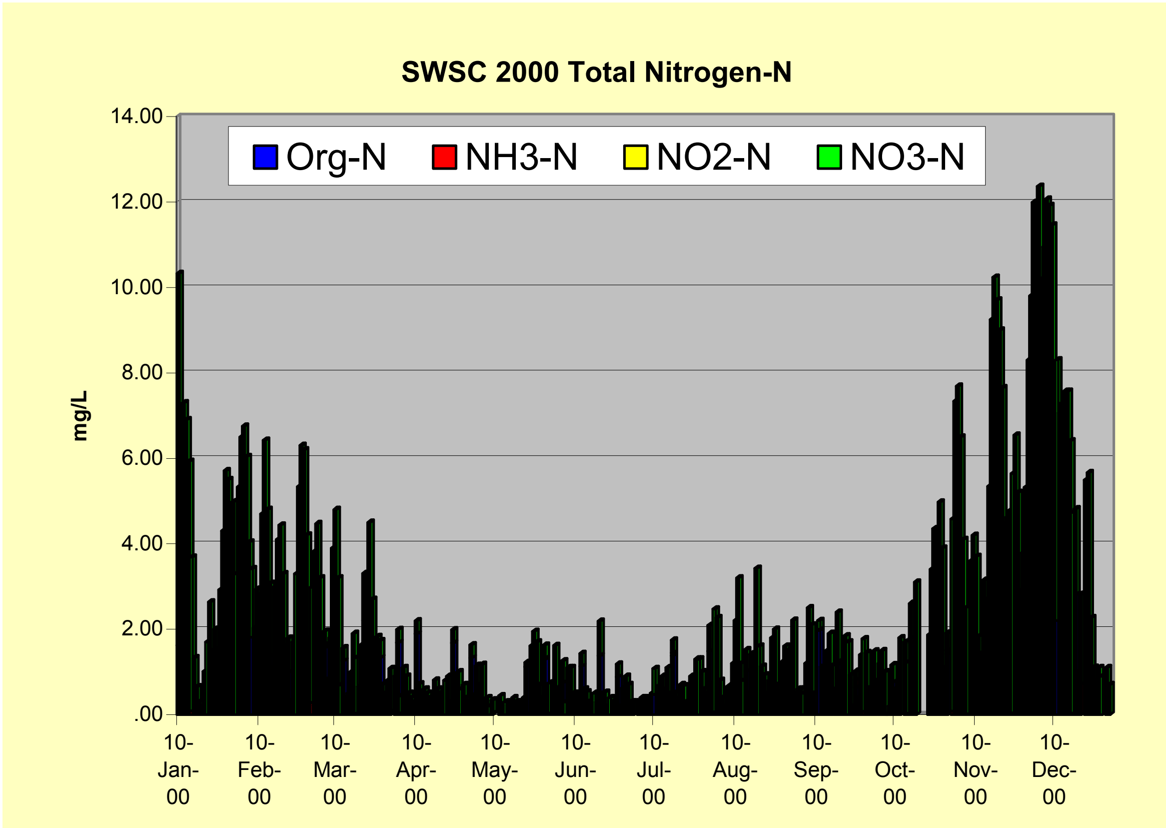

Figure 15. Graph of Total Nitrogen

Alkalinity

Alkalinity is a measure of the buffering capacity of water, the capacity of bases to neutralize acids. Alkalinity does not refer to pH, but to the ability of water to resist change in pH. The presence of buffering materials helps neutralize acids as they are added to water. These buffering materials are primarily the bases bicarbonate (HCO_3-), and carbonate (CO_3--), and occasionally hydroxides (OH-), borates, silicates, phosphates, ammonium, sulfides, and organic ligands.

$$NH_3 + H_2O \rightleftharpoons NH_4OH$$

$$NH_4OH + CO_2 \rightleftharpoons NH_4HCO_3$$

$$2NH_4HCO_3 + 3O_2 \xrightarrow{\text{Nitrosomonas}} 2HNO_2 + 4H_2O + 2CO_2$$

$$2HNO_2 + O_2 + 2HCO_3^- \xrightarrow{\text{Nitrobacter}} 2NO_3^- + 2H_2O + 2CO_2$$

Figure 16. Nitrification

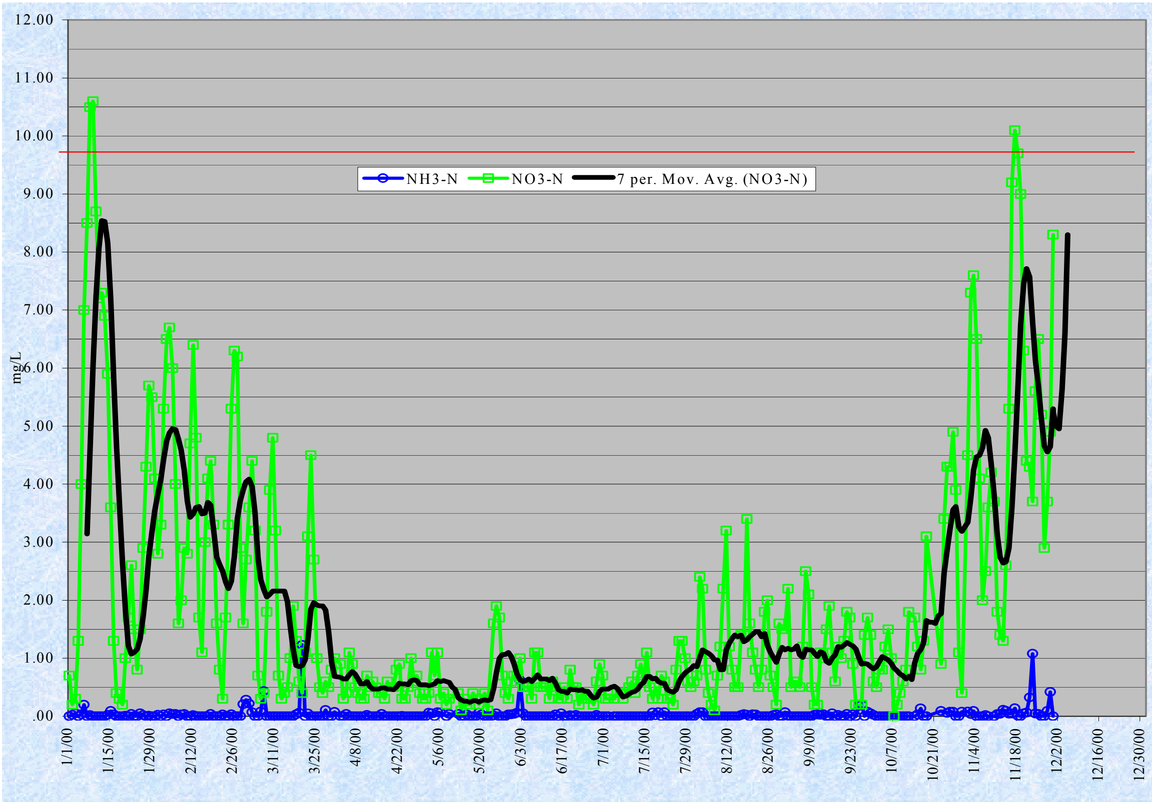

Figure 17. Graph of Nitrate and Ammonium

Because alkalinity varies greatly due to differences in geology, there aren't general standards for alkalinity. Levels of 20-200 mg/L are typical of fresh water. A total alkalinity level of 100-200 mg/L will stabilize the pH level in a stream. Levels below 10 mg/L indicate that the system is poorly buffered, and is very susceptible to changes in pH from natural and human-caused sources (Alkalinity, 1997).

At SWS, soda ash [Sodium carbonate ($Na_2 CO_3$)] is used to boost alkalinity because ammonium (urea) uses up alkalinity. Every pound of NH_4 reduces Alkalinity by 7.1 pounds.

Example: 30 lbs. of NH_4 x 7.1 = 213 lbs. (of alkalinity required)

If there is 300 lbs of alkalinity and ammonium requires 213 lbs, 87 pounds of alkalinity are left.

For every pound of NO_3, 5.4 pounds of soda ash are needed.

So, 30 lbs. NO_3 x 5.4 = 146 pounds of soda ash required.

This is added back into the alkalinity:

87 + 146 = 233 pounds. So net loss from 300 pounds of alkalinity, is ~ 67 pounds

It is essential to keep alkalinity > 100 mg/L in the aeration basin. To insure this an additional 100 mg/L of alkalinity is added to the influent, since alkalinity will be used up in the nitrification process. If the alkalinity < 50, pH can drop precipitously. There is no alkalinity effluent measurement, but SWS must comply with a constant pH between 6-9 s.u.(Figure 17).

For all the above reasons, ammonium and BOD concentrations from the LAC influent will require careful consideration. Appendix F contains the results of data from Los Alamos County wastewater system during August 2000 for alkalinity, phosphorus and total nitrogen (J. Ayers, SWS Plant Operator, Personal Communication, 5/15/01).

APPENDIX B

Feasibility Study by Jacobs Engineering, Inc.

TABLE OF CONTENTS

1. Introduction

LANL has requested a study by Jacobs Engineering Group, Inc. to investigate the feasibility of diverting waste water from the Los Alamos County collection system to the LANL Sanitary Waste System Collection, (SWSC), Plant Outfall located at the abandoned Trickling Filter Plant. The primary reasons for the diversion are:

a. Increase the flows to the Plant on the weekends and holidays;
b. Increase the concentration of BOD in the Plant influent;
c. Increase the microorganism live cycle and viability in the Plant reactors;
d. Provide the operators of the SWSC Plant and the Bayo Canyon Plant flexibility in influent allocation based on their needs and goals. This includes additional treated effluent that could be potentially used for cooling water within the LANL site.

The objectives of this study are:

a. Assemble data on the existing lift stations, pumps, force mains, gravity lines and manholes in the LANL and County service areas;
b. Prepare a hydraulic modeling of possible diversion options; and
c. Present feasibility study construction cost opinions for the considered options.

Two potential alignments were investigated, Option A1 and Option A2, in bringing County waste water flows into the LANL collection system based on available routes and hydraulic modeling results. These are shown in Figure 1-4. This report presents the results of the engineering analysis and hydraulic modeling in support of the preferred alignment, proposed lift station, gravity and force main line improvements and pump upgrades.

2.0 Team Members

NAME	ORGANIZATION
Chris Sanchez	Los Alamos National Laboratory
Ed Hoth	Los Alamos National Laboratory
Claire Kerven	Los Alamos National Laboratory
Steve Hanson	Los Alamos National Laboratory
Charlie Barnett	Johnson Controls Northern New Mexico
Mark Trujillo	Johnson Controls Northern New Mexico
Tim Glasco, P.E.	Los Alamos County Utilities
Steve Cummins	Los Alamos County Utilities
Clay Mosley	Los Alamos County Utilities
Mark Johnson, P.E.	Jacobs Engineering Group
Larry Pinkel	Jacobs Engineering Group
Bob Lenyk, P.E.	Jacobs Engineering Group
Joe Chato, PE LS	Red Mountain Engineering, Inc.
Tom Andrews, PE	Red Mountain Engineering, Inc.

3. Project Description

Los Alamos County Utilities has identified a location in their collection system where approximately 0.23 MGD daily average flow and 0.57 MGD daily peak flow can be diverted. This flow information was provided by Steve Cummins, County Utilities, based on his recent modeling results. The location for the diversion is southwest of Los Alamos High School in an existing easement. A Proposed Lift Station (PLS) can be located in the approximate center of a triangular shaped site located on the northeast corner of the intersection of Diamond Drive and Canyon Road as shown on Figure 1-4. LANL has a portion of their collection system approximately 1200 feet immediately south of the PLS location. An existing lift station TA 43-10 and associated 6-inch cast iron force main are located at the southeast side of the Health

Research Laboratory (HRL) as shown on Figures 1-1, 1-2, and 1-3. The 6-inch cast iron force main runs east from TA 43-10 to a point called J-1 in the hydraulic model of this study. Waste water then flows south into Los Alamos Canyon under Omega Road to East Jemez Road and then continues west along East Jemez Road. At a point approximately 930 feet west of the intersection of Diamond Drive and East Jemez Road, the 6-inch force main turns south and discharges into a location documented approximately 120 feet south of manhole MH 61-690. Total 6-inch cast iron force main length from Lift Station 43-10 is approximately 3100 feet. Then the waste water flows by gravity through an 8-inch vitrified clay pipe (VCP), an 8-inch concrete pipe and an 8-inch or 10-inch polyvinylchloride (PVC) pipe. The gravity lines flow into the wetwell of lift station TA 03-693. The PVC gravity line is shown as 8-inch on the lift station TA 03-693 plans and 10-inch on the sewer plans obtained for this study. The 8-inch PVC is used for purposes of this study. A 4-inch steel force main carries the waste water from lift station TA 03-693 approximately 780 feet to the 678 Outfall (Figure 1-3) at the abandoned Trickling Plant. The 678 Outfall is a junction box with inlet pressure and gravity lines and an outlet line feeding the SWCS Treatment Plant.

4. Options

Two potential alignments were investigated, Option A1 and Option A2, in bringing County waste water flows into the LANL collection system based on available routes and hydraulic modeling results

A. OPTION A1

Build the PLS on the northeast corner of Diamond Drive and Canyon Road. Route the PLS force main east on Canyon then immediately south on 39th Street past Gold then across Trinity Drive continuing south past the Boiler Plant. Connect to the existing 6-inch cast iron force main coming from TA 43-10 Lift Station at junction J-1 as shown on Figures 1-1 and 1-4. This option allows the PLS and Lift Station 43-10 to operate in parallel combining and balancing their hydraulic energy at junction J-1. Table 1-1 and 1-2 provide capacity of the gravity sections for full and half flow respectively. Table 1-3 provides a summary of the Lift Station Hydraulic Modeling.

B. OPTION A2

Another option became apparent after initial modeling runs. Construct the PLS on the northeast corner of Diamond Drive and Canyon Road. Route the PLS force main east on Canyon then immediately south on 39th Street past Gold then across Trinity Drive. Then route the 6-inch PVC force main west through the parking lot in front of the Medical Center to the northwest corner of the building. As shown in Figure 1-4, the proposed line turns south and connects to the existing and abandoned 4-inch cast iron (CI) force main located in the parking lot between the Center and the HRL. This option has the PLS discharging into Lift Station TA 43-10 wetwell and the pumps operating in tandem. Pump hydraulics in Option A2 offer increased flows if required. Table 1-1 and 1-2 provide capacity of the gravity sections for full and half flow respectively. Table 1-3 provides a summary of the Lift Station Hydraulic Modeling.

5. Project Justification

A recent video camera inspection performed by LANL of the gravity section south of East Jemez Road shows tree root development through joints and gaps in connections as well as chunks of concrete in places. Replacement of pipe in this section is proposed and will be necessary to carry the diverted flows. The performance of the SWSC Treatment Plant will be improved as a result of added organic and hydraulic loading. Loads will be reduced by approximately 0.23 MGD average to the Bayo Canyon Plant. The additional treated effluent from the SWSC can be used for cooling water purposes, thus conserving resources and reducing the need to purchase water.

6. <u>Relationship To Other Projects</u>

There are no direct relationships to other construction projects.

7. <u>Assumptions</u>

The following assumptions have been included in this study and are included as the basis for the cost estimate:

- One connection to the PLS at the High School will be made from an existing manhole located approximately 300 feet to the north.
- Another connection to the PLS will be made from an existing manhole approximately 65 feet to the southwest.
- Other utilities will be encountered when constructing the force main from the PLS to the TA 43-10 lift station.
- Lift Station TA 03 -693 may have to be modified to accept larger pumps. Approximately 900 feet of older VCP and concrete gravity line will be replaced with PVC. No costs for modifying lift station will be included in the estimates.
- The 6-inch cast iron forcemain from TA 43-10 to the gravity section south of East Jemez Road is a major component of Option A1. This line requires investigation for possible

internal fouling and exterior corrosion. This activity has not been scheduled nor is it part of this report. The cost for this activity is not included in the estimates.

- Elevations used for the hydraulic modeling are those appearing on LANL and County documents of record. These data are from different original documents and may have different benchmarks. All elevations must be field verified prior to final design. The elevations are sufficient to support the conclusions of this feasibility report.

8. Alternate Considerations

Alternative alignments for the PLS force main were considered in this study. However, detailed evaluations of existing utility documentation and field investigations are required before selecting the final design alignment and lift station and pump configurations.

9. Basis - Feasibility Study Construction Cost Estimate

Unit costs are chosen for the PLS on a lump sum basis, the PLS force main on a lineal foot basis, and gravity lines on a lineal foot basis. Special construction such as boring and jacking is required for the PLS force main placement under the intersection of Trinity Drive and 39th Street. Lump sum and unit costs are based on current bid tabulations, the latest R.S. Means Construction Cost Data, Jacob's construction cost estimators, and internal cost experience at Johnson Controls Northern New Mexico (JCNNM). Flow meters are added to obtain information to operate the diversion efficiently and effectively. Unburdened feasibility study construction cost estimates are shown in Appendix B for Options A1 and A2.

10. Preferred Option

The Preferred Option is Option A1 per review meeting dated March 15, 2001. This decision was developed primarily based upon overall cost and the desire to keep construction out of the hospital’s parking lot area. The feasibility study construction estimate, fully burdened, based upon a design/build concept with all adders is shown in Appendix C.

Unburdened Feasibility Study Construction Cost Estimate Option A1

Unburdened Feasibility Study Construction Cost

Estimate

LANL LA County Waste Water Diversion Option A1

ITEM NO.	DESCRIPTION	UNIT	QTY	UNIT PRICE	AMOUNT
1	PLS GRAVITY LINE, 8" PVC	LF	240	$100	$24,000
2	PLS TIE-IN TO LAC MH	LS	2	$1,000	$2,000
3	PLS, INCLUDING ELECTRICAL	LS	1	$100,000	$100,000
4	PLS FORCEMAIN, 6" PVC	LF	985	$100	$98,500
5	PLS FORCEMAIN, 6" JACK & BORE	LF	105	$200	$21,000
6	PLS FORCEMAIN TIE-IN TO 6" STEEL	LS	1	$5,000	$5,000
7	6" CV & GV TIE-IN TO 6" STEEL FM	LS	1	$8,000	$8,000
8	TA 03-693 PUMPS REPLACEMENT	LS	1	$40,000	$40,000
9	FLOW METERS	EA	2	$6,000	$12,000
10	GRAVITY LINE, TA 3, 8" PVC	LF	700	$100	$70,000
11	GRAVITY LINE, TA 3, CONNECTIONS	EA	12	$600	$7,200
	TOTAL OPTION A1				$387,700

Unburdened Feasibility Study Construction Cost Estimate Option A2

Unburdened Feasibility Study Construction

Cost Estimate

LANL-LA County Waste Water Diversion
Option A2

ITEM NO.	DESCRIPTION	UNIT	QTY	UNIT PRICE	AMOUNT
1	PLS GRAVITY LINE, 8" PVC	LF	240	$100	$24,000
2	PLS TIE-IN TO LAC MH	LS	2	$1,000	$2,000
3	PLS, INCLUDING ELECTRICAL	LS	1	$100,000	$100,000
4	PLS FORCEMAIN, 6" PVC	LF	1777	$100	$177,700
5	PLS FORCEMAIN, 6" JACK & BORE	LF	105	$200	$21,000
6	PLS FM TIE-IN TO TA 43-10 LS	LS	1	$5,000	$5,000
7	TA 03-693 PUMPS REPLACEMENT	LS	1	$40,000	$40,000
8	FLOW METERS	EA	2	$6,000	$12,000
9	GRAVITY LINE, TA 3, 8" PVC	LF	700	$100	$70,000
10	GRAVITY LINE, TA 3, CONNECTIONS	EA	12	$600	$7,200
	TOTAL OPTION A2				$458,900

Fully Burdened Feasibility Study Construction Cost Estimate Preferred

Option A1

LANL - LA County Waste Water Diversion Project	Engineering Study Construction Estimate	
	(all figures in thousands of dollars- $000)	
Design/Build		$490
6.0625% NM tax		$ 30
Subtotal Design/Build Contract		$520
LANL Engineering PM Oversight		$10
LANL Engineering CM Oversight		$ 4
Procurement Costs		$5
JCNNM Costs		$4
LANL Environmental Study/Assessment		$72
LANL Construction PM Oversight		$25
LANL Construction CM Oversight		$50
Other Project Costs		$41
G&A		$15
Subtotal		$745
Escalation		$15
Contingency		$190
Total Project Cost		$950

Basis of Estimate

Design/build includes the cost of engineering design, construction and engineering construction support
Engineering design is $78,000 of the design/build cost, construction is $390,000 of the design/build cost
LANL PM Engineering Oversight is 12% of design cost (including NMGRT)
LANL CM Engineering Oversight is 5% of design cost (including NMGRT)
Procurement Costs is 1.115% of construction cost (including NMGRT)
JCNNM hook-up costs are 1% of construction costs (including NMGRT)
An environmental study/assessment is required at $50,000. A 43% GA is added to this cost.
LANL PM Construction Oversight is 6% of construction cost (including NMGRT)
LANL CM Construction Oversight is 12% of construction cost (including NMGRT)
Other Project Costs are computed at 10% of the construction cost (including NMGRT)
G&A at 14% of the first $100,000 on each contract. The contracts included are the design/build and JCNNM only.
Escalation is estimated at 2% primarily for the construction period in the 3rd and 4th qtrs of CY01
Contingency is 25% applied to all costs for an engineering study construction estimate.

Design-Build Engineering Estimate for Feasibility Study Preferred Option A1

Design/Build Engineering
Estimate for Feasibility Study

LANL-LA County Waste Water Diversion Preferred
Option – A1

(all cost in thousands of dollars-$000)

ITEM	DESCRIPTION	UNIT	QTY	UNIT PRICE	AMOUNT
1	PLS Gravity Line, 8" PVC	LF	240	$100	$24
2	PLS Tie-in to LAC MH	EA	2	$1,000	$2
3	PLS, Including Electrical	EA	1	$100,000	$100
4	PLS, Forcemain, 6" PVC	LF	985	$100	$100
5	PLS, Forcemain, Jack & Bore	LF	110	$200	$22
6	PLS, Forcemain Tie-in to 6" steel	EA	1	$5,000	$5
7	6" CV & GV Tie-in to 6" Steel FM	LS	1	$8,000	$8
8	TA 03-693 Pumps Replacement	EA	1	$40,000	$40
9	Flow Meters	EA	2	$6,000	$12
10	Gravity Line, TA 3, 8" PVC	LF	700	$100	$70
11	Gravity Line, TA 3, Connection	EA	12	$600	$7
12	Design Engineering	EA	1	$78,000	$78
13	Engineering Support During Construction	EA	1	$22,000	$22
				TOTAL	$490

DESIGN/BUILD

Basis of Estimate

The engineering costs were based on this project being performed as a Design-Build contract.
Lengths of underground pipelines were estimated by take-offs from existing plot plans.
Unit prices were developed by experienced construction cost estimators based upon experience are recent contracts
The basis was the draft feasibility study report text and drawings.
Unit prices are not in thousands of dollars.

APPENDIX C

National Environmental Protection Act (NEPA) Review

NEPA REVIEW
LAN-00-

Project/Activity Title: ***Addition of LA County Influent to SWCS***		Accession No: 8144 LAN-00-	Date: 12/4/00
Location: TA-46, TA-41, TA-43	Schedule: FY 01-02	Cost: $500K	
DOE Program Office: DP	Non-DOE Sponsor:		
Project Contact: Claire Kerven (ckerven@lanl.gov), E-DO, MS J568, 505-665-4320			
Preparer/Contact: Jacie Siino , LANL ESH-20 Signature: Jacie M Siino	NEPA Reviewer: Jacie Siino , LANL ESH-20 Signature:		

DESCRIPTION OF PROPOSED ACTION:

LANL proposes to divert Los Alamos County influent to the LANL Sanitary Waste Consolidation System (SWCS). Approximately 200-300,000 gallons per day of residential influent would be diverted from the western and northern communities in Los Alamos. Influent would be available to the SWCS during evenings, weekends, and holidays, when influent is in short supply. The proposed project would improve the routine efficiency of the SWCS, as well as reduce the risk of a catastrophe which could shut the plant down. In addition, a substantial amount of effluent would be available for reuse, which would stretch the current supply available for maintenance or growth of LANL programs.

Influent would be diverted at a manhole near Los Alamos High School. A splitter with a slide gate would be installed to allow the volume of influent to be regulated. From the manhole, influent would go to a lift station to be installed either at Los Alamos High School or at the Episcopal Church. It would then be pumped along 39th Street, across Canyon and Trinity Drives, and into the Health Research Laboratory (HRL; TA-43-1) force main to TA-41 and finally to TA-46 where the SWCS plant is located. The project would require installation of a new lift station and a new line from the lift station to the HRL force main. An additional line would be installed from the SWCS to the TA-53 cooling towers.

The specific route and infrastructure locations have not yet been determined. After specific locations are identified, LANL cultural and biological resources staff would survey the areas to ensure that no cultural resources or sensitive biological resources exist in the area. All water quality requirements, including submittal of a Notice of Change Condition of NPDES Permits, would be complied with as identified by LANL's water quality staff. Best management practices would be followed to minimize erosion during construction activities.

(See continuation sheet)

NEPA DETERMINATION BASED ON ABOVE DESCRIPTION:

☐ Covered by prior NEPA review: _____, LAN- - _____,

☐ Requires EIS: 10 CFR 1021, Subpart D, Appendix D

☐ LANL recommended CX: 10 CFR 1021, Subpart D, Appendix B

☐ CX exception - Prepare EA (refer to appropriate sections of 10 CFR 1021 for full definition (check all that apply)):

- ☐ extraordinary circumstances (410(b)(2):
- ☐ threaten violation of regulation (Subpart D, Appendix B (1)):
- ☐ uncontrolled release of hazardous substance (Subpart D, Appendix B (3))
- ☐ connected action (410(b)(3):
- ☐ siting or expansion of waste TSD facility (Subpart D, Appendix B (2))
- ☐ adverse effect sensitive resource (Subpart D, Appendix B (4))

☒ None of the above: Prepare EA. [If applicable :10 CFR 1021, Subpart D, Appendix C]

☐ Other: _____

NEPA REVIEW
LAN-00-

Continuation Sheet:

The proposed project may result in increased effluent release. Excess effluent would be diverted to TA-53, to be used in existing cooling towers discharging to NPDES outfalls. Effluent flow to these NPDES outfalls may significantly change effluent volume. This flow, and how it may affect wetlands, is currently being evaluated by the LANL biologists.

NCO CLASSIFICATION/DETERMINATION:

Signature: Date:
Elizabeth Withers, NEPA Compliance Officer

APPENDIX D

SWS Effluent BOD (mg/L) from April 2000–April 2001

SWS EFFLUENT BOD (mg/L) FROM APRIL 2000 – APRIL 2001

Date	BOD (mg/Liter)	
4/4/00	<2	
4/13/00	<2	
4/19/00	1.3	
5/4/00	2.1	
5/24/00	2	
5/31/00	2.4	
6/15/00	1.8	
6/16/00	<2	
6/21/00	<2	
7/6/00	<2	
7/13/00	<2	
7/19/00	<2	
8/2/00	<2	
8/10/00	<2	
8/16/00	<2	
9/7/00	<2	
9/15/00	<2	
9/20/00	<2	
10/11/00	<2	
10/12/00	<2	
10/18/00	<2	
11/7/00	1	
11/15/00	<2	
11/21/00	1.2	
12/6/00	1.1	
12/8/00	1.5	
12/13/00	1.6	
1/10/01	1.5	
1/17/01	1.2	
1/18/01	1.3	
2/6/01	1.8	
2/15/01	1.8	
2/21/01	1.4	
3/7/01	1.9	
3/14/01	25	This outlier may have been due to short-lived toxicity or an analysis error; nothing unusual was observed by operators.
3/22/01	1.4	
4/4/01	3.3	
4/18/01	1.4	
4/25/01	3.1	

Between April 1,2000 and May 1,2001. All data are based on composite samples. The date given is the day the samples were collected and analyzed. The samplers were generally set up about 24 hours before. Results are given as estimates of < 2 mg/Liter if none of the dilutions depleted the dissolved oxygen at least 2 mg/liter over five days as required by Standard Methods.

APPENDIX E

Results of Data Sampled from Los Alamos County Wastewater System

Date: Mon, 10 Apr 2000 11:15:22 -0600
To: ckerven@lanl.gov
From: "Marke W. Talley" <talley_marke_w@lanl.gov>
Subject: Los Alamos County Sanitary Waste Characterization

The attached file summarizes the results of the operational tests we performed on sanitary wastewater we collected with Los Alamos County personnel on March 30 and April 4. These tests included pH, Microtox screening (per cent respiration inhibition), Total Dissolved Solids, Total Suspended Solids, Biochemical Oxygen Demand (BOD), and Chemical Oxygen Demand (COD).

Both sets of samples were collected midmorning from a lift station on DP road opposite Fire Station # 2, from a lift station on Fairway, and a from a manhole by the south end of the Los Alamos High School. Charles Barnett, UWWS, selected these locations as representative of the area that may be piped to SWSC to increase buffering capacity at the LANL wastewater plant.

Low TSS (total suspended solids) in all samples may correspond to the fact that many residents are at work. Nelson Edmonds, Los Alamos County Utilities, agreed to collect samples from the two lift stations as early as possible after he arrives at work this next Wednesday.

The data are variable, as you would expect. I hope they will be useful for the meeting on April 13.

Marke

Los Alamos County Manhole Characterization April, 2000

Manhole Location, Date/time	Acidity: pH s.u.	COD/BOD (mg/Liter)	Microtox Screen % inhibition >50%= toxic	Total Suspended Solids (mg/Liter)	Total Dissolved Solids (mg/Liter)
Fairway 3-30-2000, 10:10	7.3	COD 432 BOD 130	27 %	124	300
Fairway 4-4-2000, 10:15	8.5	COD 528 BOD 250	84 %	145	130
LA High 3-30-2000 10:30	8.5	COD 545 BOD 175	78 %	65	460
LA High 4-4-2000 10:20	7.8	COD 467 BOD 225	69 %	164	208
DP Road 3-30-200 10:40	7.6	COD 201 BOD 35	13 %	4	448
DP Road 4-4-2000 10:40	7.7	COD 402 BOD 115	36 %	99	308

X-Mailer: QUALCOMM Windows Eudora Pro Version 4.2.0.58
Date: Fri, 17 Nov 2000 10:33:58 -0700
To: ckerven@lanl.gov
From: Marke Talley <Talley_Marke_W@lanl.gov>
Subject: Here's one set of data

I thought maybe you'd like to see these data so I got one set together - preliminary, not yet proofed. You'll see several BOD values of >300. I'm sorry I can't be more specific and let you know whether that means 400 or 600. We ran 2% influent for each BOD so that we had 24 bottles to track. If you need to average the values, I think I'd chose 450 as an arbitrary/reasonable approximation.

Marke

County Sewage Characterization (Lemon Lot Manhole) October 23/24, 2000

Sample Number	Sample Time	.pH S.U.	BOD Mg/liter	COD Mg/Liter	Microtox % effect
1	09:30 am	6.9	210	402	70
2	10:30	6.9	>305		82
3	11:30	6.8	205	447	82
4	12:30 pm	7.0	195		74
5	01:30	7.4	>320	599	87
6	02:30	7.8	230		78
7	03:30	9.0	>305	754	67
8	04:30	7.4	190		64
9	05:30	7.3	170	374	75
10	06:30	8.1	230		89
11	07:30	7.7	170	331	70
12	08:30	7.4	165		72
13	09:30	7.5	145	264	67
14	10:30	8.0	135		75
15	11:30	7.9	125	213	51
16	12:30 am	8.0	120		55
17	01:30	7.9	110	226	46
18	02:30	7.8	90		38
19	03:30	7.7	55	177	21
20	04:30	7.9	145		35
21	05:30	8.2	>320	303	44
22	06:30	8.3	>320		63
23	07:30	8.1	>320	388	64
24	08:30	8.0	1215		85

X-Mailer: QUALCOMM Windows Eudora Pro Version 4.2.0.58
Date: Fri, 17 Nov 2000 16:22:21 -0700
To: ckerven@lanl.gov
From: Marke Talley <Talley_Marke_W@lanl.gov>
Subject: Here's the rest of our data: October 25/26
Hi Claire -

Here are the rest of our HENV data. I'll add the Assaigai results on the four composite samples we took when we receive them.
Marke

County Sewage Characterization (Lemon Lot Manhole)   October 25/26, 2000

Sample Number	Sample Time	.pH S.U.	BOD Mg/liter	COD Mg/Liter	Microtox % effect
1	09:00 am	7.7	200	359	59.3
2	10:00	8.1	165		57.9
3	11:00	7.4	145		61.9
4	12:00 noon	8.1	205	331	51.3
5	01:00	8.4	130		70.4
6	02:00	6.9	195		67.7
7	03:00	6.5	>300	415	47.9
8	04:00	7.2	220		39.4
9	05:00	7.6	80		37.7
10	06:00	7.5	160	331	57.4
11	07:00	7.2	190		58.4
12	08:00	7.6	200		60.5
13	09:00	7.6	165	374	59.6
14	10:00	7.5	220		75.1
15	11:00	8.2	175		58.5
16	12:00 am	7.8	135	252	50.8
17	01:00	7.8	90		29.5
18	02:00	7.6	90		35.8
19	03:00	7.8	75	165	16.3
20	04:00	Empty			
21	05:00	Empty			
22	06:00	7.7	4		17.8
23	07:00	8.0	165		50.5
24	08:00	9.6	450	915	66.3

X-Sender: 068397@chaco.jci.lanl.gov
X-Mailer: QUALCOMM Windows Eudora Pro Version 4.2.0.58
Date: Wed, 06 Sep 2000 16:51:20 -0600
To: Barnett_Charles_H@lanl.gov, Talley_Marke_W@lanl.gov, BBeers@lanl.gov,
Marquez_Ramiro_D@lanl.gov, Saladen_Michael_T@lanl.gov,
Trujillo_Mark@lanl.gov, Vardaro@lanl.gov, smithour_mell_a@lanl.gov,
forte_jerry_a@lanl.gov, SuzanneM@lanl.gov, Deyloff_John_L@lanl.gov,
ejhoth@lanl.gov, cpulskamp@becorp.com, vyd@lanl.gov, gmontoya@lanl.gov,
ckerven@lanl.gov
From: "Marke W. Talley" <talley_marke_w@lanl.gov>
Subject: Los Alamos County Sanitary Wastewater Study
Cc: glascot@lac.losalamos.nm.us
X-RCPT-TO: <168307@mail-48.lanl.gov>

The results of the HENV analysis of 24 sanitary wastewater samples collected near the Methodist Church on Diamond Drive on August 31 and September 1 is attached. I wrote the data in a word table in hopes they would reach you unscrambled. If you have any problems opening the memo, please call me at 667-0105 or respond by e-mail to let me know if you would like me to send you a copy by mail or by fax machine.

Many thanks to Ramiro Marquez, Jeff Ayers, and Mark Casados, UWWS, for figuring out a way we could collect these samples in a public area without causing risk to passers by or vandalization of the sampling equipment!

Marke

CountyWW8-00.doc

JOHNSON CONTROLS NORTHERN NEW MEXICO

INTEROFFICE MEMORANDUM

TO: Charles Barnett, UWWS
FROM: Marke Talley, Environmental Laboratory Team Leader, HENV
===

DATE: September 6, 2000 MEMO # HENV. **00-127**

SUBJECT: LOS ALAMOS COUNTY SANITARY WASTEWATER STUDY

As you requested, HENV analyzed 24 discrete samples of Los Alamos County sanitary wastewater for BOD, COD, pH, and microtox. The purpose of this study is to help the SWSC/WAC committee evaluate the possibility of routing domestic sewage from the county to the SWSC collection system to increase its biological load and decrease its sensitivity to toxic influent.

Mark Casados and Jeff Ayers, UWWS, set up a discrete manhole sampler at a manhole in the parking lot next to Diamond Drive and east of the Methodist Church at 7:55 am on August 31. The sampler was made secure by locking it in a utilities truck parked over the manhole overnight. They brought the samples to HENV for analysis.

Chris Pulskamp analyzed all the samples for pH and microtox percent effect. I analyzed all 24 for COD and BOD. The results are summarized in the attached table. I analyzed two samples for TDS and TSS. The 9-1 1:55 am sample demonstrated TDS of 616.7 mg/L, TSS 320.2 mg/L. The sample collected at 8:55 am on September 5 demonstrated values of 473.3 mg/L TDS and 274.0 mg/L TSS.

Sample pH ranged from 6.8 to 8.4 s.u.. Most of the samples showed a pH of about 7.5. Actual pH of the samples was probably a little lower. Most samples lose carbon dioxide when exposed to air for several minutes. Samples collected overnight were exposed to air for at least 6 hours.

BOD ranged from 80 mg/L to 250 mg/L. Most of the samples collected during daylight hours were over 240 mg/L. Samples collected after midnight ranged from 80 to 180 mg/L. COD ranged from 155 to 2,395 mg/L with an average of 703 mg/L. The actual BOD and COD values are probably 30-50 % higher than those shown in the table because I took no special care to homogenize the samples and because the dissolved oxygen depletion of seven of the samples was out of range.

Microtox toxicity ranged from 31 to 66% with an average of 51%, which is about 15% higher than typical TA-46 influent toxicity. Toxicity was lowest in the dilute samples collected after midnight.

Marke Talley, Environmental Laboratory Supervisor

Los Alamos County Sanitary Wastewater collected 8:55 am 8-31 through 7:55 am 9-1-00

Time	Acid/base pH s.u	BOD Mg/Liter	COD Mg/Liter	Microtox % effect at 15 minutes
8:55 am 8-31	7.8	>240	940	41 %
9:55	7.6	180	650	46
10:55	7.2	>240	765	53
11:55	7.1	>240	765	66
12:55 pm	7.5	130	650	57
1:55	7.1	>240	1130	60
2:55	7.3	>240	825	57
3:55	7.2	>240	2395	60
4:55	7.2	235	940	65
5:55	7.4	180	540	56
6:55	7.6	170	1065	56
7:55	7.3	>240	825	61
8:55	6.8	>240	1195	57
9:55	7.2	250	540	60
10:55	7.2	185	595	40
11:55	7.4	130	650	60
12:55 am 9-1	7.6	180	485	61
1:55	7.6	110	485	43
2:55	7.5	110	155	42
3:55	7.0	80	265	32
4:55	8.1	110	155	30
5:55	8.1	100	315	42
6:55	7.8	110	210	40
7:55	8.4	135	315	43

APPENDIX F

Los Alamos County Bayo Canyon Influent Results for Total Alkalinity, Total Phosphorus, and Total Kjeldahl Nitrogen (August 2000)

Anachem, Inc.

Date: *10-Aug-00*

CLIENT: Los Alamos County
Work Order: 0008043
Project: Influent WK3

Analyses	Result	Limit	Units	Date Analyzed

Lab ID: 0008043-01A
Client Sample ID: #7 WK3 TKN,ALK — **Collection Date:** 7/31/00
Location: Bayo Canyon WWTP, L.A., NM — **Matrix:** LIQUID

0008043-01A **BatchID:** R6835	**ALKALINITY, TOTAL (EPA 310.1)**		**Prep Date:**	**Analyst:** SD
Alkalinity, Total (As CaCO3)	256	1	mg/L	8/10/00
0008043-01A **BatchID:** R6768	**NITROGEN, TOTAL KJELDAHL (EPA 351.3)**		**Prep Date:**	**Analyst:** SD
Nitrogen, Kjeldahl, Total	26.5	0.05	mg/L	8/4/00

Lab ID: 0008043-02A
Client Sample ID: #8 WK3 TKN,ALK — **Collection Date:** 8/1/00
Location: Bayo Canyon WWTP, L.A., NM — **Matrix:** LIQUID

0008043-02A **BatchID:** R6835	**ALKALINITY, TOTAL (EPA 310.1)**		**Prep Date:**	**Analyst:** SD
Alkalinity, Total (As CaCO3)	264	1	mg/L	8/10/00
0008043-02A **BatchID:** R6768	**NITROGEN, TOTAL KJELDAHL (EPA 351.3)**		**Prep Date:**	**Analyst:** SD
Nitrogen, Kjeldahl, Total	2.95	0.05	mg/L	8/4/00

Lab ID: 0008043-03A
Client Sample ID: #9 WK3 TKN,ALK — **Collection Date:** 8/2/00
Location: Bayo Canyon WWTP, L.A., NM — **Matrix:** LIQUID

0008043-03A **BatchID:** R6835	**ALKALINITY, TOTAL (EPA 310.1)**		**Prep Date:**	**Analyst:** SD
Alkalinity, Total (As CaCO3)	262	1	mg/L	8/10/00
0008043-03A **BatchID:** R6768	**NITROGEN, TOTAL KJELDAHL (EPA 351.3)**		**Prep Date:**	**Analyst:** SD
Nitrogen, Kjeldahl, Total	32.4	0.05	mg/L	8/4/00

Qualifiers: ND - Not Detected at the Reporting Limit
B - Analyte detected in the associated Method Blank

Page 2 Of 3

Anachem, Inc. **Date:** *21-Aug-00*

CLIENT: Los Alamos County
Work Order: 0008225
Project: Bayo Canyon Influent WK5

Analyses	Result	Limit	Units	Date Analyzed

Lab ID: 0008225-01A
Client Sample ID: TKN & P/ALK #13 WK 5 — **Collection Date:** 8/14/00
Location: Bayo WWTP, L.A., NM — **Matrix:** LIQUID

Analyses	Result	Limit	Units	Date Analyzed
0008225-01A ALKALINITY, TOTAL (EPA 310.1) BatchID: R6967 — Prep Date: — Analyst: SD				
Alkalinity, Total (As $CaCO_3$)	234	1	mg/L	8/18/00
0008225-01A PHOSPHORUS, TOTAL (EPA 365.2) BatchID: R6963 — Prep Date: — Analyst: SD				
Phosphorus, Total (As P)	7.24	0.02	mg/L	8/19/00
0008225-01A NITROGEN, TOTAL KJELDAHL (EPA 351.3) BatchID: R6965 — Prep Date: — Analyst: SD				
Nitrogen, Kjeldahl, Total	39.1	0.05	mg/L	8/19/00

Lab ID: 0008225-02A
Client Sample ID: TKN & P/ALK #14 WK 5 — **Collection Date:** 8/15/00
Location: Bayo WWTP, L.A., NM — **Matrix:** LIQUID

Analyses	Result	Limit	Units	Date Analyzed
0008225-02A ALKALINITY, TOTAL (EPA 310.1) BatchID: R6967 — Prep Date: — Analyst: SD				
Alkalinity, Total (As $CaCO_3$)	252	1	mg/L	8/18/00
0008225-02A PHOSPHORUS, TOTAL (EPA 365.2) BatchID: R6963 — Prep Date: — Analyst: SD				
Phosphorus, Total (As P)	8.97	0.02	mg/L	8/19/00
0008225-02A NITROGEN, TOTAL KJELDAHL (EPA 351.3) BatchID: R6965 — Prep Date: — Analyst: SD				
Nitrogen, Kjeldahl, Total	19.4	0.05	mg/L	8/19/00

Lab ID: 0008225-03A
Client Sample ID: TKN & P/ALK #15 WK 5 — **Collection Date:** 8/16/00
Location: Bayo WWTP, L.A., NM — **Matrix:** LIQUID

Analyses	Result	Limit	Units	Date Analyzed
0008225-03A ALKALINITY, TOTAL (EPA 310.1) BatchID: R6967 — Prep Date: — Analyst: SD				
Alkalinity, Total (As $CaCO_3$)	236	1	mg/L	8/18/00
0008225-03A PHOSPHORUS, TOTAL (EPA 365.2) BatchID: R6963 — Prep Date: — Analyst: SD				
Phosphorus, Total (As P)	11.1	0.02	mg/L	8/19/00
0008225-03A NITROGEN, TOTAL KJELDAHL (EPA 351.3) BatchID: R6965 — Prep Date: — Analyst: SD				
Nitrogen, Kjeldahl, Total	30.2	0.05	mg/L	8/19/00

Qualifiers: ND - Not Detected at the Reporting Limit
B - Analyte detected in the associated Method Blank

Anachem, Inc. Date: *19-Sep-00*

CLIENT: Los Alamos County
Work Order: 0009027
Project: Bayo Plant Influent Wk 6

Analyses	Result	Limit	Units	Date Analyzed

Lab ID: 0009027-01A
Client Sample ID: #16 Wk 6 P **Collection Date:** 8/29/00
Location: Bayo Canyon WWTP **Matrix:** LIQUID

0009027-01A **PHOSPHORUS, TOTAL (EPA 365.2)** **Prep Date:** **Analyst:** KH
BatchID: R7208

Phosphorus, Total (As P)	4.32	0.02	mg/L	9/8/00

Lab ID: 0009027-02A
Client Sample ID: #16 Wk 6 TKN **Collection Date:** 8/29/00
Location: Bayo Canyon WWTP **Matrix:** LIQUID

0009027-02A **NITROGEN, TOTAL KJELDAHL (EPA 351.3)** **Prep Date:** **Analyst:** KH
BatchID: R7338

Nitrogen, Kjeldahl, Total	19.4	0.05	mg/L	9/19/00

Lab ID: 0009027-03A
Client Sample ID: #17 Wk 6 P **Collection Date:** 8/30/00
Location: Bayo Canyon WWTP **Matrix:** LIQUID

0009027-03A **PHOSPHORUS, TOTAL (EPA 365.2)** **Prep Date:** **Analyst:** KH
BatchID: R7208

Phosphorus, Total (As P)	4.16	0.02	mg/L	9/8/00

Lab ID: 0009027-04A
Client Sample ID: #17 Wk 6 TKN **Collection Date:** 8/30/00
Location: Bayo Canyon WWTP **Matrix:** LIQUID

0009027-04A **NITROGEN, TOTAL KJELDAHL (EPA 351.3)** **Prep Date:** **Analyst:** KH
BatchID: R7338

Nitrogen, Kjeldahl, Total	17.9	0.05	mg/L	9/19/00

Lab ID: 0009027-05A
Client Sample ID: #17 Wk 6 Ammonia **Collection Date:** 8/30/00
Location: Bayo Canyon WWTP **Matrix:** LIQUID

0009027-05A **NITROGEN, AMMONIA (EPA 350.2)** **Prep Date:** **Analyst:** SD
BatchID: R7345

Nitrogen, Ammonia (As N)	11.3	0.05	mg/L	9/12/00

Qualifiers: ND - Not Detected at the Reporting Limit
B - Analyte detected in the associated Method Blank